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Utilization Abstracts

Book Reviews

Agriculture and Economic Development in Indonesia[1]

Like occasional other articles in Economic Botany, this one is little concerned with botany or plant utilization. Instead, it is a study in agricultural economics and social development in a part of the world where plant products, long produced under colonial management, have been significant items in development.

STANLEY LEVY
Harvard University

Introduction

In the earliest stages of a nation's economic development, agricultural production and the production of other primary goods have a greater relative importance than they are likely to have at any subsequent level of development. When a nation is in the earliest stages of economic advancement, the production of primary goods comprises the greatest proportion of the entire economic capabilities of the country. Industry and industrial development, at best, are then taking their first shaky strides, and often they are still in the planning or formative stages. Countries at this level have an overwhelming desire to develop economically; in particular, to develop industrially. Wisely employed, primary production can be used as the initial step up the ladder of development. If primary production is to be used as the impetus for further advancement, it must be considered as one part of a complex economy, a single part of a greater whole. Paradoxically, as this segment of the whole is successful in increasing its total contribution to the economy, its own relative importance in the economy declines. This relative decrease in importance is inevitable and generally desirable, for only by freeing the people from their complete dependence upon the land, and by developing economically and industrially, will such countries become capable of offering to their citizens the higher standards of living which modern civilization has proven it can provide.

Indonesia is a primary producing country which is economically underde-

[1] The editor herewith gratefully acknowledges the assistance of Mr. W. J. Edens, Agricultural Attaché, Djakarta, Indonesia, for his critical reading of this article in manuscript and for various suggested alterations which have been made in it.

veloped when judged by western standards. In many respects Indonesia is a typical underdeveloped country of southeast Asia. Agriculture in Indonesia has played and will continue to play a significant role in the economy of the country and in its future economic development. Directly or indirectly, agriculture and primary production provide work for 80 percent of the total Indonesian labor force. The agricultural goods produced by this portion of the population comprise two-thirds of the value of all Indonesian exports. Moreover, the rural sector of the economy is responsible for 57% of the national income (36) and for a major share of the revenue of the Government.

The structure of the agricultural sector quite naturally affects the methods and efficiency of production, and in turn, the sector's contribution to the economy as a whole. Conversely, the economic conditions of the nation, its social structure and values, its political ideals and organization affect the structure, efficiency and future development of the agricultural sector. A careful study of agriculture in Indonesia will illustrate the interrelationship of the agricultural sector with the entire economy, and the very important role which the agricultural sector does and must continue to play in the development of Indonesia.

Physical Factors and Their Importance

As a nation, neither the 80 million Indonesians nor the physical factors which shape their lives are homogeneous. The islands of Indonesia are a part of the Malay Archipelago and lie between the southernmost extension of the Asian land mass and the northern part of Australia. This belt of islands extends over a distance of 3,000 miles and covers 600,000 square miles, a region almost equivalent to the combined areas of Washington, Oregon, California, Montana, Idaho and Nevada. Indonesia straddles the equator, and, despite the great length of the country, only a few scattered islands lie more than ten degrees from the equator.

A gentle, tropical, monsoon climate prevails throughout most of the country. The temperature variation from one region to another is negligible. As is to be expected in a country of this size, the weather may vary significantly. Indonesia has no real dry season because the intense heat of the tropical mornings tends to produce thunder showers almost every afternoon. Because of this, rainfall is sufficient for agriculture throughout the country, even in the dry monsoon periods.

Unlike the generally uniform climatic conditions, the type and quality of the soil may vary markedly from area to area. In a study of Indonesian agriculture made for the United States Department of Agriculture, John Metcalf notes that there are three types of soil in that part of the world: " 1.—those of volcanic origin, usually fertile and of good texture; 2.—those of the alluvial plains, fertile but rather heavy; 3.—those of tertiary origin, poor and heavy " (31a). The importance of the rich volcanic soil cannot be overestimated when careful consideration is given to Indonesian agricultural development.

Having once realized that there can be, and often are, differences in soil, topography, climate and weather conditions, it is safe to assert, in general terms, that the natural conditions in Indonesia have been extremely favorable for the development of many different and varied crops, as well as for the growing of two and even three crops in a single year.

Structure of Indonesian Agriculture

A double dichotomy characterizes the structure of Indonesian agriculture. First, there is a geographical dichotomy

between production on Java and Madura, and production on the outer islands. This dichotomy has its roots in the early Dutch administrative practices which treated Java as distinct from the other islands of the Archipelago. Despite the later Dutch and Indonesian attempts at greater integration, this dichotomy still tends to persist. The second dichotomy is the functional one between the plantation type of production of the estates and the peasant type of production of the small holders. This functional dichotomy also traces its origin back to the early Dutch practices which developed a plantation economy for export to Holland and left to the native population the task of producing enough food for the islands.

Fifty-two million of the 80 million people of Indonesia are squeezed onto the 66,000 square miles of island that is Java. It takes little arithmetic talent to convert this to a percentage figure that shows that 74 percent of the total population lives on only nine percent of the land, while the remaining 91 percent of the land, the outer islands, holds only 26 percent of the population, or 18 million people. To put the contrast into still sharper focus, the population density of Java varies from 900–1400 per square mile, while it is only 44 persons per square mile on the outer islands.

Sixty-five percent of the land on Java is under intense cultivation. In many areas, because of the naturally favorable conditions, two and sometimes

FIG. 1. Cutting each stalk individually makes rice harvesting an expensive and time-consuming operation.

three harvests are possible each year. Even with such favorable conditions, the prospect of Java ever being self-sufficient in food production appears slim. Indeed, the increasing population growth, the shortage of new land for future cultivation and the vital fact that the once fertile soil is showing telltale traces of exhaustion are all factors which combine to question the future vitality of the island.

As soon as attention is shifted from Java to the outer islands, one is struck by an almost contrary situation. The islands are characterized by a sparse population which relies on a shifting, burning type of agricultural production (ladang). Where there are plantations on the outer islands they are usually highly specialized, capital intensive[2] and suffering from a shortage of labor. This paradoxical situation, the over-supply of labor relative to the under-supply of land on Java, while an under-supply of labor and an over-supply of land existing concurrently on the outer islands, has led the Indonesian Government to attempt a policy of transmigration of people from Java to the outer islands. The Government sees in the transmigration policy a one-pronged attack on a three-fold problem. If the policy is successful, the Government feels it will alleviate the problem of over-population on Java. At the same time it will tend to produce a more satisfactory relation between the two important factors of production in both regions. Transmigration should help solve the labor shortage on the outer islands, while the decrease in population from Java may lead to improved efficiency of production and to an increase in the amount of land under cultivation, which will result in an increase in the total agricultural output. Up to the present, however, the increase in the Javanese population has been greater than transmigration rate.

The functional dichotomy between the estates and the small holder is generally equated with a dichotomy between production for export and production for domestic consumption. Linkage of estates with exports and linkage of food production with the small holders had a degree of validity in the past, and is still useful for purposes of analysis. But care must be exercised not to treat the end product of production as something synonymous with the producing group. It is true that the estates produce comparatively little for domestic consumption; it is not true that the small holders produce only food crops. Many peasant crops, and in increasing volume, are finding their way into the world markets.

The small holder produces for the subsistence of himself and his family on an average of 2.1 acres of land. He has a net income of 12 rupiahs a day[3], which permits him a far from adequate standard of living. Most of the small holders grow rice, which is the staple food of Indonesia, corn, cassava, sweet potatoes, soy beans and peanuts. The small scale of production of the average small holder saddles him with many disadvantages which will be discussed later. However, the small scale yields to the peasant the advantages of flexibility of action and choice of crops. When the price of the export crops shifts upwards, the small holder can shift his crop to gain the full benefit of this temporary advantage. Though he does shift, it should be remembered that the small holder is, first, a subsistence farmer; secondly, a producer for the local market; and only marginally, an exporter for the world market.

[2] "Capital intensive" and "labor intensive" methods of production are distinguished according to whether capital or labor is the predominating factor.

[3] At the current rate of exchange, $1 is equivalent to 11.40 rupiahs.

FIG. 2. The "milk" of the rubber tree runs along the tapper's oblique incision into receptacle cup.

The estates are large plantations which were begun, operated and controlled by western interests, primarily Dutch, and were oriented toward the world market. They are managed in western ways and are operated with western equipment and techniques. Because of their external outlook, the estates are unusually subject to the violent economic fluctuations which are normal in world trade. The estates had an extremely favorable balance of trade position in 1950 and 1951 as a result of a rise in demand and in prices for their goods caused by the Korean War. Coffee, oil palm, rubber and other goods were all favorably affected, and the estates reaped the harvest during those years. With the easing of tension in 1952 and 1953, the prices of primary goods declined and the demand slacked off. The estates had to tighten their belts and bear the drought as they had reaped the fruits of the good times.

The major problem which Indonesia and Indonesian agriculture must face is how to keep the supply of food increasing at a rate proportional to that of population growth. The Indonesian population is increasing at the pace of 1.5%, or 1.2 million persons per year. The land of Java is already under intensive cultivation, and the prospect of bringing new land under cultivation is slim. The pressure of the increasing population creates difficulties for economic development as well as the more straightforward problems that arise in simply feeding the already large population. Population increases lead to a decreased rate of capital accumulation [4] and to a lowering of the per capita income of the country. The resources of the country are diverted from accumulation and use in developing the real income potential to the feeding of the increasing population, the greater portion of whom may never reach an age of economic profitability. In a recent study for the Twentieth Century Fund, Buchanan and Ellis (6) claim that raising children is a social investment which yields little in return in economically underdeveloped countries.

TABLE I

POPULATION, AREA UNDER CULTIVATION, AND AMOUNT OF RICE IMPORTED INTO INDONESIA

Year	Population (millions)	Area under cultivation (million acres)	Rice imported (tons)
1930	60.7	...	......
1940	70.4	10.4	200,000
1950	78.0	10.4	325,000

(Bank of Indonesia reports and Metcalf).

At this point, the purpose of this article is not to study the problems but merely to note the existence of them. Their effect and the efforts of the Government to cope with the food problem will be explored more fully later.

Background

In 1949, after four years of violent disputes, the Dutch and the Indonesian representatives decided that the sovereignty over the islands in the East Indies should be transferred to Indonesian control. The new governors of Indonesia found themselves in control of a country, fortunate by the graces of nature though wracked by the actions of man. Five years of Japanese domination had produced all the destruction and dislocation which usually accompany foreign occupation. Instead of obtaining the peace which it so desperately wanted and needed, Indonesia was forced to undergo a four-year war with

[4] Capital accumulation is an accumulation of productive, real, capital resources, not of money as is commonly thought. A recent book on economic development defines accumulation as existing only when the year's total output is such that at the end of the year the kinds and quantities of useful equipment in existence are superior to those of the preceding year.

the returning Dutch colonial administrators. As a result, any attempts to bring about early reconstruction were completely nullified.

The two major external forces which had shaped the structure of Indonesian agriculture were quite different. The first formative factor was the questionably progressive Dutch colonial practice which actually laid the foundations of Indonesian agriculture. The second factor was the definitely destructive forces unleashed by the Japanese occupation and the later Dutch "police action". This latter factor reshaped and remodeled the earlier Dutch foundations.

The colonial policy of the Dutch, over the long period of their control of the Indies, was to develop an agricultural plantation economy which would have definite economic value to the motherland. This policy marked the early twentieth century Dutch policy as clearly as it had marked the policy of the early Dutch East India Company. The Dutch practices of importing and developing economically valuable plants from other areas of the world for growth in the Indies, of operating agricultural experimental stations and seed farms, of carrying on extensive work in hybridization and selection, and of distributing the newly acquired information and techniques throughout the country constituted as great a benefit to the small holders as to the estates.

FIG. 3. Women picking ripe coffee beans on Sumatra.

Bernard Vlekke (53) expresses the view that that the Indies were wealthy only because of the Dutch practices:

> The Indies, the islands of fabulous wealth, are in reality a very poor country. Only by introducing western skills and methods of production could the exports be raised. . . . Patient research, technical skill and courage created the new sources of wealth the Indies needed.

There is a good deal of validity in this statement. The Indies are naturally rich, but this wealth is not wealth of an immediate commercial value. Also, many of the major Indonesian food

crops, like corn, soy beans and peanuts, are not native to Indonesia, nor are many of the export crops like cinchona, oil palm, tea and coffee. Other important crops, for instance, rice and copra, were developed into commercially valuable crops through Dutch research and experimentation. There is no doubt that the Dutch contribution to the commercial importance of Indonesia in the world market has been great. But the Dutch practices were not designed to benefit the Indonesian people. The practices were aimed at developing an agricultural export economy which was only artificially mature, an economy which was significantly dependent upon Holland.

Under Dutch influence Java was developed into a huge plantation area which produced crops for export, mostly to Holland. It was only after 1910 that efforts to develop the outer islands were seriously undertaken. Between 1900 and 1937, $2263 million were invested in the East Indies. Seventy-five percent of this money came from Dutch sources, and the greatest portion of it was oriented toward the development of the outer islands.

Quite naturally the Dutch colonial administrators favored their own countrymen, and many of their policies indicated this national favoritism. However, in 1870 the colonial administrators passed an Agricultural Land Law which excluded all foreigners, Dutch included, from owning any land in Indonesia. This land law, combined with certain communal customs, has been a major reason for the failure of any radical land reform movement to develop, as well as for the failure of the development of any large native land-owning class.

While the law prohibited foreign ownership of land, it did not seriously hamper development of the plantations. The estates were able to obtain land on short-term leases from private sources or on longer-term leases from the Government. In many cases the estates and the Government worked together to improve crop yields and quality, and, even more important, in passing the newly acquired information on to the small holder through the Government extension service.

By 1937, 71 million acres of land were under lease to the estates, and the estates were producing 60 percent of the agricultural exports of the country and over 40 percent of the revenues of the Government. Because of their high level of production and the fine quality of Indonesian goods, Indonesia was able to obtain large shares of the world markets of such products as quinine, sugar, rubber, tea, copra and coffee. Production of food crops was left to small holder farming, which, surprisingly enough, was able to produce enough food to feed the population of the Indies. Until the Japanese invasion and occupation, Indonesian food production was able to keep pace with the demands of the populalation, though it was never sufficiently large to rise above the subsistence level.

The Japanese occupation was a major disruptive shock to the Indonesian economy. Many of the Dutch administrators and managers were interned in concentration camps, others fled the country. Production on the estates was completely disrupted. The carefully developed and cultivated estates were allowed to deteriorate. Some estates were diverted to other uses, while still others were destroyed. The lands of many of the estates were divided among the small holders or were simply usurped by them.

The condition of the country after the occupation was serious. Instead of the rapid rehabilitation hoped for, the agricultural sector was further injured by the struggle for independence which finally resulted in the transfer of sov-

TABLE II

WEIGHT AND VALUE OF INDONESIAN EXPORTS

Source	Weight (m.t.)		Value (million Rp.)	
	1938	1950	1938	1950
Estates ...	8,725.43	7,079.12	309.60	888.08
Small hold.	1,885.43	1,127.14	182.62	1,434.18
Total ..	10,550.86	8,206.26	492.22	2,322.26

(Hollinger, The Export Economy).

ereignty. In some places the destruction of public works and valuable crop land, which is the usual result of warfare on a nation's own land, was accentuated by a use of scorched earth tactics.

By 1950 the production of food was still below the 1938 level, while the population had increased by eight million people. As Table II indicates, though the value of the Indonesian exports has increased over the 1938 level, the total physical volume has fallen below that level. The young Government was faced by external foreign pressures as well as internal insecurity. The loyalty of many regions was uncertain and the Government was far from being an efficiently operating organ. All and all, the conditions under which the new Republic was born were not notably auspicious.

The Food-Producing Sector

The major problem confronting the new Indonesian Government was to find some method of increasing food production so that it could keep pace with the growing demands of the expanding population. It was not until 1950 that the production of food attained the prewar 1938 level, but by that time the population had increased greatly. This meant that Indonesia had to import 325,000 tons of rice in 1950 and almost 400,000 tons in 1951. Rice constituted a major part of the country's total imports, and such imports were a significant drain on the Indonesian foreign exchange balances. Not only was the 1950 domestic supply insufficient to meet the demand, but the Government realized that at the estimated 1.5% per year increase in population the demand would increase by 100,000 tons per year. Furthermore, the price of rice in the world markets was very high, and the prospects of a price reduction were doubtful. So, from the point of view of humanitarian needs and political expediency as well as from sheer economic necessity, it was of prime importance that the nation's food production attain a level of self-sufficiency as rapidly as possible.

In addition to the major crops indicated in Table III and next discussed individually, others, too, are grown for food, including potatoes (*Solanum tuberosum* L.), yams (*Pachyrrhizus erosus* (L.) Urban.), arrowroot (*Maranta arundinacea* L.), taro (*Colocasia antiquorum* Schott.) and a wide selection of gourds, vegetables, melons and other fruits.

TABLE III

PRODUCTION OF MOST IMPORTANT FOOD CROPS IN INDONESIA, IN '000 TONS

	1938	1951	1952	1953	1954
		Java			
Rice (irrigated)	3682	3659	3907	4163	4471
Rice (non-irrigated)	239	121	133	143	193
Maize (hulled)	2037	1550	1750	1500	2084
Cassava (root)	7637	7200	7500	7560	7500
Sweet potatoes (root)	1182	950	1256	1231	1053
Peanuts (peeled)	181	162	127	163	202
Soy beans	269	254	263	288	361
		Outer islands			
Rice (irrigated)	...	1600	1621	1887	
Rice (non-irrigated)	...	425	447	499	
Maize	...	800	861	916	
Cassava	...	700	732	772	
Sweet potatoes	...	80	84	88	
Peanuts	...	22	30	33	
Soy beans	...	16	15	16	

(Bank of Indonesia Reports).

Rice (*Oryza sativa* L.) Gramineae.—Rice is the economic foundation of native agriculture in Indonesia, particularly on Java. It is grown in three ways: *a*) sawah or wet cultivation, usually making use of an extensive irrigation system; 90% of Java's rice is a product of this type of cultivation; *b*) padi gogo or upland dry cultivation; and *c*) ladang or shifting fire farming which is prevalent on the outer islands.

The tropical climate allows a full growing year if sufficient water is available. Over nine and one-half million acres of land on Java and six million acres on the outer islands are devoted to the cultivation of rice in some form. However, the rice yield averages only about 1500 pounds per hectare, which is considerably below the 2200 pounds that China's farmers attain or the 3300 which is the average yield in Japan.

The growing of irrigated rice is extremely laborious and time-consuming. The rice is grown in small inundated paddy fields which are supplied with water either by means of an irrigation system or by damming up the rains in the open sawah. To prepare the land for cultivation, the dikes must be repaired before the fields are flooded. Then the water is allowed to soak the fields for two or three days before the field is plowed and planted. The rice seedlings are transplanted from seed farms, many of which are Government-operated. Planting takes place from November through January, at the beginning of and during the wet monsoon. After planting there is little to do until the rice is harvested four months later. At that time the fields are drained, and the harvesting, which, like the planting, is the job of women, takes place. The women use a sharp, small sickle and cut each rice stalk individually. The stalks are then banded together in 15-pound sheathes and laid out in the sun to dry. About 80% of the harvest is used on the farm where it is threshed and husked by hand. The surplus is sold to rice mills and eventually finds its way into the distributive system.

After the harvest of the sawah rice, the fields are replanted with a second rice crop if there is sufficient water, or with some secondary crop.

In 1953 the rice crop increased to such an extent that only 100,000 tons of rice were imported, and even that was used only as an emergency reserve. The Government announced early in 1955 that in the year ending December, 1954, there had be no imports of rice and that the country was self-sufficient for the first time since 1938. There were many reasons for this significant increase, among them increased use of fertilizer, careful seed selection, greater use of modern methods and implements, the prolonged rainy season and the small holders reverting to the cultivation of rice because of a fall in the market price for rubber.

Further extension of rice-growing on Java is unlikely. All the land suitable for the purpose is already being used. In fact, possibly too much land is being used. Agronomists and forestry experts estimate that between 25% and 30% of the land on Java should be under forest to maintain an adequate water supply and to prevent erosion. At present only 23% of the land is under forests. Part of this danger must be attributed to the demands for new land for food, but that is far from being the entire story. The Indonesian forests are very wealthy. They yield rattans, resins, spices, camphor, tannin, guttas as well as firewood, charcoal, timber and other woods with many varied uses. Native demands and commercial attractions have also caused inroads on the vital forest land. In an attempt to combat this danger, the Government has been pursuing an extensive program of

reforestation, and there is a fair chance that, in the not too distant future, Indonesia will be able to have her forests and use them, too, to corrupt an old proverb.

Corn (*Zea Mays* L.) Gramineae.—Corn is the second most important food plant in Indonesia. It grows on land not well suited for production of rice, primarily on Central and East Java, Bali, Lombok and the lesser Sundas. By 1950 the amount of land devoted to corn production was equal to the 1938 amount, but, due to exhaustion of the soil and the poor yields, the output was still significantly below the prewar level.

Zea Mays is native to the western hemisphere, and it seems unable to gain a real foothold in Asia except on land that is unsuitable for rice. Corn has been known in the East Indies since the XVII century, but it was only during the latter part of the XIX century that it rose to any great importance.

Favorable climatic conditions on Java make possible three distinct harvest periods a year. Two corn crops can be grown in succession on dry upland fields (tegallons), while a secondary crop can be grown in the sawah fields in the dry season. Corn is used as a substitute for rice in the native's diet, while corn starch is utilized in puddings and the unripe ears serve as vegetables. The natives use the green leaves as cigarette wrappers, the stalks as fodder and the dried corn as cattle feed.

FIG. 4. Picking tea leaves on a Sumatran plantation.

Attempts have been made in Java to hybridize corn to improve its yield, the experiments being carried out at the famous agricultural station at Bogor. If the land is becoming exhausted, as

many experts believe, cultivation of corn and other secondary crops will become more important in the future of Indonesian agriculture.

Cassava (*Manihot esculenta* Crantz.) Euphorbiaceae.—Cassava is the third most important food crop in Indonesia. The roots are pulled up, quartered and dried in the sun; then ground to make a gaplek meal. While cassava has less food value than rice or corn, it has a compensating virtue, the ability to grow on relatively poor land. For this reason it is becoming significantly important on Java, while it remains insignificant on the outer islands. Production of cassava tends to vary inversely with periods of food scarcity.

Cassava is native to South America and probably came to the Indies through efforts of the Dutch. It is a dry land crop which takes from seven to nine months to mature. The plant tends to be on the lowest rung of growers' preferences, but a rung they eventually fall to as soil fertility declines. Besides being used as food, cassava is employed to produce tapioca which is a large Indonesian export. In making tapioca, the roots are peeled and then grated. The milky juice, expressed during the grating, is soaked in water for a few days. After the soaking, it is kneaded and strained to remove impurities, then dried and cooked to produce the tapioca of commerce.

Sweet Potato (*Ipomea batatas* (L.) Poir.) Convolvulaceae.—Sweet potato was one of the three plants known in both the old and the new world before 1492. It is generally considered a native tropical American plant, and its use in Indonesia is as a secondary crop on irrigated rice fields. Sweet potato contains both starch and sugar as well as a little fat. The edible part is the tuberous root, grown as an annual and propagated vegetatively. It has a very low yield, but experts believe that the yield could be increased if the plant were given proper study. In Indonesia sweet potato is a common native food which seldom reaches the market places of the larger cities.

Peanut (*Arachis hypogea* L.) Leguminoseae.—Peanuts and soy beans, are the principal legumes grown in Indonesia. They are raised on dry land and ripen in less than four months. The peanut is not noted as a tropical plant but it has grown well in the area. Professor Burkhill believes that it, a native of South America, was carried to Asia by the Portuguese, and came to Indonesia by way of China.

Peanut production was below prewar levels as late as 1953. When peanuts are eaten, they are usually roasted, and their high calorie content (one pound yields 2700 calories) provides a great addition to a calorie-scanty diet. Large quantities are used to produce peanut oil for export, and the residual cake is utilized as a sweet meat or as a concentrated cattle feed.

Soy Bean (*Glycine max* (L.) Merr.) Leguminosae.—The soy bean has become important in Indonesia only since 1932. After the world war, cultivation of it was slow but it is now above prewar levels. Soy bean is native to southeast Asia and is known to have been cultivated in China before 3000 *B.C.* It is a rich source of protein (30–45%) and of fats (18–22%), two scarce items in the diet of most Indonesians.

The possible uses of soy bean are innumerable, but its main role in Indonesia is as a food. Two years ago an article in the New York Times[5] mentioned that the Indonesian Government was constructing a factory to produce three quarts of synthetic milk from one pound of soy beans. The beans are cultivated primarily on Java, though there is some cultivation on almost all of the

[5] Financial page, March 3, 1955.

islands. The yield however, is quite low—600-650 pounds per acre, which is about half of the American yield. Attempts are being made to improve both the yield and the quality of the crop.

* * * * *

In their effort to increase the food supply, the Government has used a number of methods simultaneously, and many problems have had to be overcome. The average small holder owned approximately 2.1 acres of land and therefore had to suffer all the economic disadvantages of small-scale production. Most of his crop had to be devoted to the subsistence of his family. He could bestow little time, land or capital to the production of cash crops. Unable to produce for the market, he had little capital for purchasing fertilizer and for making improvements, both of which are necessary if output is to be increased. He was unable to take advantage of what some writers have called " the improvement circle of development ". Better yields lead to the production of cash crops which in turn yields capital that can be used for improvements and for fertilizer which in turn will produce higher yields.

The Government made an effort to come to the small holders' aid. In 1951, with the aid of an American Economic Cooperation Administration grant, it was able to distribute 450,000 tons of fertilizer at considerably reduced costs. Yet, even at reduced rates there was a marked degree of reluctance and of inability to purchase the fertilizer and to use it. It took a good deal of time and effort by the Government officials before the fertilizer was productively used by the small holders. The Government also resumed the research and experimental work which the Dutch had begun. New seed farms were started and those already in existence were expanded. Probably the major contribution of the Government was the work it did in improving and expanding the irrigation system so there would be enough water for double cropping of rice. Corn-breeding projects are now being pursued, and the Government also undertook some land reclamation projects and urged the small holders to make greater use of modern methods and implements. However, after the collapse of the export market in 1952, economy measures forced the Government to reduce the scope of its program and to curtail some of its projects.

The farmers were able to meet and overcome some of their problems through participation in the various cooperatives. Indonesia has five types of cooperative designed for the following purposes: *a*) to improve agricultural methods; *b*) to serve as societies for land rent; *c*) to serve as savings and loan cooperatives; *d*) for collective sale of agricultural products; *e*) to serve for purchase of agricultural equipment. The cooperatives offer the Indonesian farmer one way of overcoming the capital deficiency which is hindering his development. They provide the small holder with a place where he can obtain credit for his short-term needs. It can also be a place and a force to mobilize savings, as Table IV indicates. Equally important, it can use the accumulated savings to bring about productive investments.

A major share of the success of this sector of the economy can be attributed to the cooperative movement, which has the support of the Indonesian Government, particularly of former Vice-Presi-

TABLE IV

INDONESIAN COOPERATIVES

Year	No. of cooperatives	Membership	Savings of members
1950	900	100,000	Rp. 35,000,000
1954	8,606	1,150,000	" 76,000,000

(Bank of Indonesia Report).

dent Hatta. However, the Indonesian cooperative movement, like the cooperative movements of other countries in southeast Asia, has not been the effective force for savings, investments and development it could be.

Production of almost all the major food crops has shown increases since 1951, as Table III indicates. The newly achieved self-sufficiency raises two important questions: First, has the condition of the average Indonesian improved as a result of the increased production? Second, can the higher output be maintained and increased to meet what will certainly be an increased demand?

It seems fair to state that the per capita consumption of the average Indonesian remains low. Though consumption has risen since 1950, it is still below western standards. Even though one accepts the view of some nutritional experts that Asiatics need less calories than do westerners, there is still little doubt that the diet is inadequate. Not only is the caloric intake insufficient, but distribution of the diet is faulty. It is composed primarily of carbohydrates, and there is a need for more proteins and fats.

Indonesia's ability to meet the demand for food is not at all assured despite the favorable natural conditions which allow double cropping in many areas. The intensive cultivation, combined with the general non-use of fertilizer, has not only resulted in relatively low yields per acre but also threatens many areas with soil exhaustion. Table VI shows the use of fertilizer in Indonesia as compared with that in some western countries.

TABLE V

AVERAGE DAILY INDONESIAN CALORIC INTAKE PER PERSON

Year	Caloric intake
1938	2040
1950	1600
1951	1950
1953	2100

TABLE VI

USE OF FERTILIZER IN CERTAIN COUNTRIES

Country	Pounds per acre
Indonesia	0.709
Belgium	294.8
New Zealand	246.8
Switzerland	166.6

(FAO Yearbook, pp. 74–76, 1954).

Hollinger (23, p. 7) cites the peasant shift from corn to cassava as an indication of the worsening condition of the soil. On the other hand, work at the experimental station at Bogor indicates that the rice yield can be increased three hundred percent with proper use of fertilizer, selected seeds and greater attention to modernization of techniques.

Many economists and agronomists believe that there are too many people on the land to obtain the maximum yield possible. This is one example of inefficiency in the use of economic resources. In economic terms, the average small holder has a marginal productivity of zero or even of a negative quantity [6]. If this position is correct, it would mean that the output of the land could be maintained and might even be expected to increase if a share of the farm population were redeployed. One study of Indonesian agriculture discovered that the average small holder works only four and three-fourths hours per day, on the average, to produce the maximum yield of his holding (23, p. 13). Furthermore, removal of this labor from the land would provide a large labor force which might be used in other development projects. The possible productive uses of the newly found labor force and the

[6] The marginal productivity of labor is the amount of additional output obtained when one unit of labor is added but all other factors are held constant.

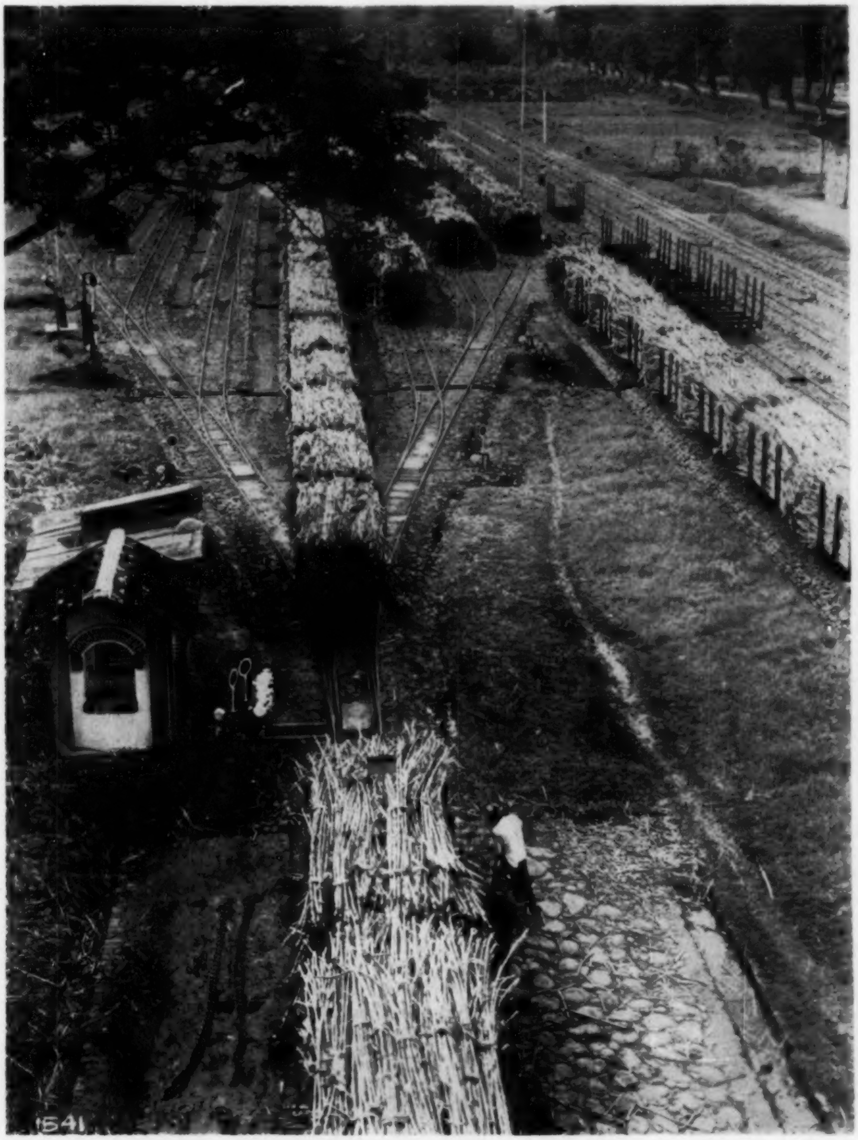


FIG. 5. Sugar cane being transported to a factory for processing.

disguised unemployment of agricultural workers will be considered later.

The Indonesian agricultural sector is undergoing a change in its structural components because of increasing population and the need of money to pay governmental taxes. The Indonesian peasant is protected from foreign exploitation by the Agrarian Land Law of 1870 which is still in existence, though in a revised form. In past years, however, a large native land-owning class has developed, and with this development there has been a corresponding increase in the number of tenant farmers and share croppers. As Dr. Paauw points out, there has been a relative shift in wealth from the urban to the rural areas and a concurrent shift of the tax burden from the rural to the urban sectors (38). He feels that the Government might consider means of taxing this newly developing source of wealth as one means of obtaining revenue, rather than allowing these capital resources to lie idle or be depelted by conspicuous consumption as is so often the case.

The landlord class has a greater marginal propensity to consume [7] and to import than does the peasant class, though most of Indonesia is suffering from the "demonstration effect" [8] caused by contact with western goods. If this group is unable or unwilling to save and invest productively, it will be to the best interests of the country to use the mechanism of the Government as a means of forcing them to save through taxation or other methods. But in following this course, the Government must take extreme care not to destroy any nascent entrepreneurial potentialities which this group might have but which it has not yet exhibited.

The Government has consciously adopted a policy of taxing the food-producing sector indirectly. In many cases of economic development, the major share of paying for the development falls on the rural sector. The Food Supply Board (JUBM), with ample storage facilities, imports or controls all rice coming into Indonesia, and attempts each year to buy about eight percent of the current domestic crop. It then feeds the rice to the markets, where prices tend to rise, and it thus performs its primary function of stabilizing prices.

The food-producing sector of the economy serves three functions in Indonesia, as it does in most other underdeveloped countries. First, it provides a source of employment for a large percentage of the total population; second, it has managed to feed the growing population; and third, it helps to pay for the economic development in other sectors of the economy.

The Export-Producing Sector

It was a mixed blessing that the transfer of sovereignty was followed by the Korean War export boom. It was a mixed blessing because the high export prices produced substantial foreign exchange earnings, which are highly beneficial, while at the same time encouraging instability and a standard of living beyond the means of the infant nation. For any country that is taking the first perilous steps toward development, the export sector serves as a source of obtaining foreign exchange earnings for necessary imports, as a means of access to foreign markets, as a disseminator of modern methods and techniques, and, through export duties, as a major source

[7] Marginal propensity to consume is measured by the additional amount of income devoted to the purchase of consumer goods, rather than being used for some other purpose.

[8] The "demonstration effect" was first recognized by Professor Dusenberry. It is the effect that western consumption goods have on people throughout the world. Although orientals do not have the earning power of western laborers, they desire the living standards of the latter. As a result, they spend whatever portion of their income they can spare on the purchase of western goods, for instance, bicycles.

of revenue for the Government. All of these benefits accrued to Indonesia as a result of her already highly developed export trade.

But in noting all the advantages which result from foreign trade, the disruptive factors often are overlooked. Most underdeveloped countries are exporters of one or two primary goods, and the world price fluctuation of primary goods tends to produce severe disequilibrium and instability within the economy, disequilibrium that is harmful to economic development. In good times there tends to be movements toward inflation and enlarged demands for consumption goods. Such was the case in 1950 and 1951, when consumption goods comprised 50% of all Indonesian imports. In times of depression the ambitious development programs of an era of good times must be tightened or eliminated in view of deficient funds.

Table VII shows the effect of the Korean boom and the aftermath in Indonesian trade. From an extremely favorable position in 1950 and 1951, the trade balance fell to an unfavorable one in 1952. As is generally true of world price fluctuations, the price of primary goods, which underdeveloped countries sell, rose proportionally more quickly than the price of the manufactured goods which they buy. At this point exports exceeded imports and there was a favorable balance of trade. But when the boom period began to level off, and the levelling off tended to be of longer duration than the rise, the relative price conditions became reversed. Table VIII of selected exports and imports shows this.

TABLE VII

INDONESIAN BALANCE OF TRADE, IN MILLION RUPIAHS

Year	Exports	Imports	Balance
1938	687	478	209
1950	3,038	1,673	1,365
1951	4,780	3,060	1,720 ($1 = Rp. 3.80)
1951	14,340	9,180	5,160 ($1 = Rp. 11.40)
1952	10,387	10,533	– 146
1953	9,344	8,584	760

(Bank of Indonesia Reports).

TABLE VIII

PRICE INDICES OF SELECTED INDONESIAN EXPORTS AND IMPORTS (1950 = 100)

Goods	1950	1951	1952	1953
Exports				
Rubber	100	172	110	96
Copra	100	124	75	95
Petroleum	100	162	153	155
Total exports ..	100	144	102	...
Imports				
Consumer goods ..	100	113	114	110
Rice	100	105	112	162
Cotton	100	143	106	94
Raw and auxiliary material	100	173	143	118
Capital good	100	105	113	139
Total import ..	100	138	131	...

(Bank of Indonesia Reports).

In 1938 the estates were responsible for 60% of the agricultural exports. In 1950, however, the contribution of the estates fell to just above 30% because the Japanese occupation was more damaging to the estates than it was to the small holder. Though the percentage has increased since 1950, there is little reason to believe that the estates will ever regain their once dominant position. During the war, many of the estates were distributed to the peasants, others were left untended, and as a result the titles to several of them are still in dispute. This has led to a marked decrease in the total land available to the estates for cultivation. The increasing awareness of the monetary market has tempted many small holders to shift from food production to that of export crops. This has resulted in an increase in the portion of the total which the small holder contributes. It is estimated that Indonesia

can produce 450,000 tons of rubber under normal conditions. To exceed this, the factors of production—land and labor—must be shifted from other uses to the production of rubber. In 1950 and 1951 over 700,000 tons of rubber were produced. This fact shows that the small holders are aware of world market conditions and that they are capable of reacting in such a way as to take advantage of favorable conditions.

rubber and oil palm do not compete with food for land. But the field crops, like tobacco and sugar, require the same type of soil and conditions as do the more important food crops. In many cases this land is now being denied them. In other instances the export crop requires a gestation period of a number of years before it attains any economic and commercial value. For many crops it was only after 1951 that they were commercially important. These factors, combined with the relative inefficiency of Indonesian management compared to their European counterparts, with insecurity and with thefts in many parts of the islands, have all had their effect in keeping the level of output down.

FIG. 6. A tobacco plantation on Java which produces the famous "Deli" tobacco.

Indonesia has been unable to recapture many of the prewar markets which were lost to other primary producing countries when the Indonesian supplies were denied to the free world. The loss of these markets and the development of new competition, including new synthetic substitutes, has had the effect of dampening any incentive to increase the output of such crops as cinchona and rubber.

Besides less land for cultivation, there are also fewer estates than before. The so-called hill crops of coffee, cinchona,

Possibly even more responsible for the low level of output are the rising costs and the labor problem. Estates are usually western enterprises and their land in Indonesia must be leased; it cannot be owned. The land is leased from the

TABLE IX

PRINCIPAL INDONESIAN EXPORTS IN PERCENTAGES

Item	1938	1950	1951	1952	1953	1955
Rubber	22.6	41.8	50.8	46.6	33.0	46.0
Coffee	...	...	...	...	4.0	1.7
Tea	8.3	3.7	2.9	2.6	2.9	3.3
Sugar	6.5	...	...	...	1.0	2.0
Tobacco	3.9	2.9	2.2	1.9	2.9	3.0
Copra	5.7	7.7	10.4	5.6	7.0	4.6
Palm Oil	2.8	3.4	3.0	3.3	4.1	2.9
Kapok	...	...	...	...	7.0	...
Spices	...	...	...	...	2.0	...

(Bank of Indonesia Report).

Government for 75–100 years or from individual landowners for one or two years. In the latter case the standard procedure is for the peasant to lease the land to the estates for cash to implement his income, work for the estate as a laborer during the growing season, and then share-crop the land after the estates' crop has been harvested. Although some estates are highly capitalized, the majority are still labor intensive, and labor is making extreme demands in present-day Indonesia. Increased wages and high fixed costs are making it difficult, in some cases impossible, for Indonesian goods to compete on world markets. Higher wages mean a higher cost for Indonesian goods, and in all probability a decrease in their share of the market. It would be natural to expect plantation management to shift to more capital intensive methods of production, but this has not happened. Because of the low margin of profit and relatively high Government taxes, the insecurity and uncertainty of future conditions, foreign capital has been hesitant about investing in the young nation. Until very recently Indonesia did nothing to encourage foreign investment, but steps are now being taken in that direction. When all the factors are added up, there is little likelihood that the estates will again become the dominant factor in Indonesian economy.

The main agricultural exports and their percentages in relation to total Indonesian exports are listed in Table IX. These goods, with the addition of cinchona bark which has some interesting historical feature, are:

Rubber (*Hevea Brasiliensis*) (Willd. ex A. Juss.) Mull. Arg. Euphorbiaceae.—Indonesia was the world's leading supplier of rubber in 1950. The Indonesian rubber industry is a relatively recent industry. It dates back to the arrival of 33 rubber trees from Brazil in 1882. Cultivation made great progress because of the scientific experimentation and governmental assistance given to the rubber estates. Rubber is Indonesia's largest single export, and the rapid rise in production in 1950 and 1951 indicates how quickly cultivation will respond to world prices. In 1950, alone, rubber exports earned over $303 million. Indonesian rubber comes from both estates and small holders. The latter produced about one-third of the 1938 total, about three-fourths of the 1950 total, but only about half by 1953.

Estates rubber is grown on Java, East Sumatra and Borneo, often at high altitudes because the lowlands are devoted to the production of food. For best growth, rubber trees require a warm moist climate, deep soil of good texture and a yearly rainfall of from 70 to 100 inches. Metcalf estimates that the rub-

TABLE X

TONS OF RUBBER PRODUCTION IN, AND EXPORT FROM, INDONESIA

Year	Estates	Small-holders	Total	Export
1935–39	186,850	167,513	354,363	338,860
1950	174,147	529,687	703,687	702,778
1951	216,588	588,283	804,488	751,508
1952	294,449	452,060	683,487	717,000
1953	306,782	378,705	685,487	688,174
1954	285,854	456,144	738,670	728,670
1955	261,345	472,441	733,786	721,786

(Metcalf and Bank of Indonesia Reports).

ber estates lost 345,000 acres of land because of the occupation, the police action and the civil strife (31a). By 1950 only half of the estates had resumed operations on about 1.8 million acres. The estates generally plant about 100 trees to the acre and then weed out the weaker trees until only about 70 are left to mature. Increased demands of the postwar years forced the estates to double their planting practices. The trees are tapped when six years old, but maximum latex yield is obtained after the tenth year. Tapping begins early in the day and is usually completed by 9:00 A.M. A thin diagonal cut in the bark is made, extending about half the circumference of the tree. The latex bleeds from this cut into a cup attached to the trunk. The trees are retapped every second day by cutting at a fresh piece of bark.

As a result of Dutch work on selection and breeding, estates rubber trees will yield 16 pounds of latex, whereas the ordinary rubber tree furnishes only five pounds. Not only is the Indonesian rubber tree more resistant to disease than wild trees, but every phase of the industry—planting, cultivation, tapping, physiology, and so forth—has been carefully studied, and widespread field tests were carried out by the Dutch.

The small holders began planting rubber trees after noting the success of the estates. The trees were set out on ladang clearings, and rice, corn or some other secondary crop was planted around them. In general the methods of planting,

FIG. 7. Some smallholders shelling coconuts for the production of copra.

maintaining and tapping used by the small holders are inferior to those pursued by the estates. It should be borne in mind that the small holder is not dependent upon the rubber crop for his subsistence. He pays little attention to it, and the low return is sufficient for the labor he expends upon the trees.

Coffee (*Coffea robusta* Linden) Rubiaceae.—Coffee, like so many other crops now being grown in Indonesia, is not native to the Indies. It was first introduced into Java in 1696, when the mocha variety of *Coffea arabica* was brought into the country. In 1870 the leaf blight attacked and exterminated this species, and *C. Liberica* was imported from Liberia. This species was not able to cope with the disease any more than its predecessor. In 1900 *C. robusta* was introduced from the Belgian Congo, and it proved to combine high productivity with resistance to the disease. It is now responsible for 90% of all Indonesian coffee.

Coffee is usually interplanted with another crop, often rubber. The coffee tree grows best on well drained land and is generally planted on hilly or sloping ground. Coffee needs at least 70 inches of rainfall a year. It takes three years before it yields any fruit, and it is not until the fifth year that a maximum yield of 500–700 pounds per acre is attained.

TABLE XI

INDONESIAN PRODUCTION AND EXPORT, IN METRIC TONS, OF COFFEE

Year	Production	Export
1935–39	117,660	81,400
1950	58,500	13,560
1951	12,055 *	23,608
1952	12,549 *	18,413
1953	60,000	32,223
1954	55,000	38,232
1955	65,000	.....

* Estates production only.
(Metcalf and Bank of Indonesia Reports).

TABLE XII

INDONESIAN PRODUCTION AND EXPORT, IN METRIC TONS, OF TEA

Year	Production	Export
1935–39	170 *	153 *
1950	78 *	70 *
1951	46,513	40,092
1952	36,860	31,872
1953	36,778	28,898
1954	46,472	44,973
1955	850,000 *	250,000 *

* Figured in one million pounds.
** Estimated.
(Metcalf and Bank of Indonesia Reports).

Table XI shows that coffee production remains substantially below its prewar level. A good deal of this can be traced to insecurity and to thefts; also to labor difficulties.

Tea (*Camellia sinensis* (L.) Ktze. Ternstroemiaceae.—Tea is essentially a plantation crop in regions where rainfall is plentiful and evenly distributed. As many as 2000 to 3000 bushes may grow on a single acre. The bushes begin bearing after the third or fourth year and have an economically valuable life for 50 years or more. Grading of tea depends on the leaf picked and the method used in drying.

Indonesia was the third largest exporter of tea before the Japanese occupation disrupted the industry. In many places tea was replaced by the production of food, ramie (*Boehemeria nivea*), pyrethrum (*Chrysanthemum cinerariaefolium*), and castor bean (*Ricinus communis*). After the war, production increased gradually until 1951, when an epidemic of the blister blight struck the Javanese tea plantations. During the Korean War boom, tea, unlike so many other export crops, did not rise in price. Labor unrest and the general lack of security have had further adverse effects on the tea industry. The high cost of labor and the fact that growing tea is a highly labor-intensive operation tend to

point to a bleak future for the Indonesian tea industry.

Tea was first introduced into Indonesia by the Dutch in 1610 from China. Serious cultivation of it did not begin until 1826 when the first Indonesian exports were entered in world markets. Assam tea, which proved to have a higher yield and a greater export popularity, has gradually replaced the Chinese tea.

Sugar (*Saccharum officinarum* L.) Gramineae.—The decline in importance of the sugar industry has been one of the major changes in Indonesian agriculture. The decline, beginning in the 1930's, was caused largely by the development of sugar growing on Formosa and continued uninterrupted until 1953. The second important factor has been the need of sugarland for food production which has acquired greater importance than any export crop. As a result, in 1955 Indonesia imported 850,000 metric tons of sugar to supplement its own production of 600,000 tons.

In the first 30 years of the XX century, 40% of the investments in estates agriculture went into sugar; sugar accounted for 25% of Indonesian exports and 15% of the world's total; sugar estates paid 10% of the income of the population of Java. These figures give an indication of the importance of the prewar industry. Yet, even then, sugar was not a socially desirable crop. The great wealth generated by sugar production went to the plantation owners, whereas the people benefited very little from the highly profitable industry.

TABLE XIII

INDONESIAN PRODUCTION AND EXPORT, IN METRIC TONS, OF SUGAR

Year	Production	Export
1935–39	1,463,000	1,186,000
1950	277,000	2,500
1951	427,000	6,326
1952	457,952	1,586
1953	619,521	101,490
1954	713,571	212,829
1955	850,000 *	250,000 *

* Estimated.
(Metcalf and Bank of Indonesia Reports).

Sugar cane is a rapidly growing perennial which was first domesticated from a wild ancestor in southeast Asia. The first supply of Javanese sugar to Europe was brought there in 1637, but a good deal of research and experimentation was necessary before the growers were able to attain the relatively pure product desired by most buyers. In 1888 the famous research station at Pasoeroan discovered that seeds are produced by the cane. This meant that selection of seed as well as propagation by grafting could be employed in improving the quality of the cane. As a result, a high yielding cane, resistant to almost all known diseases, was found (POJ 2878). In 1950 the Republic Government reopened the Pasoeroan station in the hope of increasing sugar output in Indonesia and in an attempt to recapture a part of its lost world market. If one can judge by the increases in output since 1951, the Government's hopes have been fulfilled to some degree.

Sugar is usually grown in rotation with rice on land obtained from native farmers on short-term leases. The cane is planted in September, at the beginning of the wet monsoon, and is harvested and processed during the dry monsoon, a lapse of 14 months. The estates take great care in growing the cane and usually use fertilizer. However, as the cane is a field crop, the fertile lands needed for its production will be more and more under demand for the production of food.

Tobacco (*Nicotiana tabacum* L.) Solanaceae.—Indonesian tobacco, particularly the Deli tobacco of the estates of Sumatra, is world renowned for its high quality. The Dutch planters put a great deal of research and care into the devel-

opment of their tobacco crop. Eventually they developed a unique production system which allowed the land to lie fallow for seven years after each year of planting. Tobacco is grown in other regions, but the seven-year fallow system of the Sumatran estates is not observed elsewhere in Indonesia. Deli tobacco is world-famous as a cigar wrapper, while other Indonesian tobaccos are used for binders, filler or locally for cigarettes.

Tobacco is a new world crop whose original ancestor is not known. After it was brought to the old world by the early explorers, its use and production spread rapidly.

Of all the estates' crops, the future of tobacco is the dimmest. It is unlikely that the Government, which is facing a continuous threat of a food shortage, will allow any fertile land to lie fallow for seven years when the land might be more profitably employed for food cultivation. As the long term leases of the tobacco estates expire, the Government is planning to redistribute the land. If this policy is pursued to its logical conclusion, the area devoted to tobacco cultivation will be severely curtailed.

FIG. 8. Javanese cinchona plantations produce 95% of the world's cinchona.

Copra (*Cocos nucifera* L.) Palmaceae. —The value of the coconut to tropical regions can hardly be grasped by people of the temperate areas. It is used as a source of fiber, of food and of oil, and for many other local purposes. Almost every part of the tree has some use. The present article is concerned only with the commercial value of coconut, not with its many uses.

Coconut is native to the Malay peninsula and is originally found only near the shore. The fruit is a three-sided drupe with a smooth exocarp; a reddish-brown, fibrous mesocarp; and a hard stony endocarp which encloses the seed.

TABLE XIV
INDONESIAN PRODUCTION AND EXPORT, IN METRIC TONS, OF COPRA

Year	Production	Export
1935–39	....	515,532
1950	....	292,414
1951	760,025	543,924
1952	1,003,711	347,478
1953	1,092,893	311,029
1954	1,082,505	296,855

(Metcalf and Bank of Indonesia Reports).

The plant prefers a fertile alluvial soil and lots of sunshine. Abundant water is needed but drainage is essential. 3000–7000 nuts will yield one ton of copra which in turn will furnish 1200 of oil and 800 pounds of copra cake.

In 1938 Indonesia was the world's largest exporter and the second largest producer of copra. The 1951 export totals exceeded those of 1938, but shipments have fallen somewhat since the peak year. Coconut is a small holder's crop, but intensive estates' cultivation will produce higher yields. The Government Copra Foundation purchases all that is produced, and is the sole exporter and domestic marketer of copra.

Seed coconuts are hung on rafters until the first leaves sprout and the roots push through the fibrous shell. Then they are set out in nurseries, half buried in the ground. At the beginning of the wet monsoon period, they are transplanted. The palm bears fruit in eight to ten years but does not reach full maturity until the tenth year. The fruits are picked and the husks and shells are split open. The white meat is pried out and dried in the sunlight for a few days until it shrivels and hardens into commercial copra.

The world copra price reached its peak early in 1951 and has fallen continuously since then. The decline is attributed to increased production which resulted in a saturation of the market. Generally, the export price depends on the quality of the copra and the method of drying used. Since copra is essentially a small holders' product, introduction of the expensive methods of cultivation and drying that would be needed to improve the quality is virtually impossible.

Cinchona (*Cinchona* spp.) Rubiaceae. —Ninety percent of the world's supply of cinchona was produced in Indonesia before the war. The bark of the cinchona plant, a native of the Andes of South America, yields the drug quinine, " without which there is no conquest of the tropics " (7). The plant first appeared in the Indies in 1850. Many quinine-yielding species were studied to determine which would be the most suitable in the climate and other conditions there. Finally, three species were selected for further use: *Cinchona ledgeriana*, *C. officinalis* and *C. succirubra*. Then careful work on selection and breeding of these species resulted in a fine quality of cinchona with a high yield.

Careful control by an association of cinchona growers regulated the supply and hence the price of cinchona on the world markets before World War II cut the western world from the Indonesian supplies. The Japanese attempted to maintain output for their own use, so that production was still high after the war, and subsequent decline must be attributed primarily to new sources of

TABLE XV
INDONESIAN PRODUCTION AND EXPORT, IN METRIC TONS, OF CINCHONA

Year	Production	Export of	
		Bark	Quinine
1935–39	11,200	7,040	170
1951	9,114	7,497	57
1952	3,448	2,619	2
1953	1,115	448	0
1954	1,662	....	...

(Metcalf and Bank of Indonesia Reports).

Fig. 9. Foliage and inflorescence of the cinchona tree which is the source of the malaria antitoxin, quinine.

competition from the Belgian Congo and to the wide range of synthetic anti-malaria drugs which were developed during and after the war.

Cinchona is one of the hill crops and is usually interplanted with coffee, tea or rubber. The tree thrives best in an alkaline soil at an elevation of approximately 5000 feet. The bark is richest in quinine when the tree is six years old and decreases after the tree reaches its tenth year. An acre of cinchona yields about 750 pounds of bark which in turn furnishes between 35 and 45 pounds of quinine. A great amount of research was done by the Dutch plantation owners concerning the best method of preparing the ground, the spacing and seeding of plants, fighting cinchona diseases, pruning, use of fertilization, methods of harvesting, as well as increasing and improving yields. However, the development of new synthetic substitutes will cause further reductions in the demand and in the price of the natural product. The study of cinchona in postwar Indonesia is the study of a natural product being economically destroyed by a man-made substitute.

Oil Palm (*Elaeis guineensis* Jacq.) Palmaceae.—Two distinct oils, different in many properties, are obtained, respectively, from the fibrous pulp and the kernels in the fruits of this palm which was introduced into the Indies in 1853, from Africa, by way of Holland. A trial plantation was established on Java, and after ten years of successful experimentation the palm was distributed throughout the islands. It was not until 1914 that the Indonesian oil palm became a significant factor in world markets.

The plantations use the high yielding Deli seeds and are able to obtain a yield of one to two tons per acre. The palms yield eight to ten bunches of fruit which weigh 40 to 50 pounds. 75% of the weight of a bunch is fruit; the remainder is the stalk. Once a plantation is established the cost is comparatively low. The main expenses come in harvesting and processing which are carried on throughout the year. The soil and climate of Indonesia are well suited to this palm. About 60 trees are planted to the acre, and they begin to bear fruit in three years, though it is ten years before they give their maximum yield. The fruit consists of a nut surrounded by a fleshy husk and containing the nut. The pulp is usually expressed domestically and yields about 50% oil, while the kernel is generally sent abroad for processing. Small holder production of oil palm is negligible.

The war did not affect the oil palm industry as adversely as it did other export crops. Some of the plantations were damaged but by far the most serious damage was that done to the oil-pressing installations. Recovery has been satisfactory, so that by 1953 the production of kernels was above the prewar level, while that of oil from the pulp was 85% of the prewar level.

Kapok (*Ceiba pentandra* (L.) Gaertn.) Bombaceae.—Kapok is primarily a Javanese, small holders' crop (90%). It is a fleecy white fiber which is popular because of its resiliency, lightness, buoyancy, imperviousness to water, heat-insulating and sound-absorbing qualities. The fiber, which is contained in the seed pod, is finer than cotton but is not so

TABLE XVI

INDONESIAN PRODUCTION AND EXPORT, IN METRIC TONS, OF PALM OIL

Year	Production		Export	
	Oil	Kernel	Oil	Kernel
1935–39	198,676	42,185	192,947	40,038
1950	126,476	30,777	97,006	29,095
1951	121,154	29,751	97,453	25,037
1952	145,995	38,509	120,172	37,576
1953	160,569	42,377	132,171	41,576
1954	168,325	42,287	140,106	42,595

(Metcalf and Bank of Indonesia Reports).

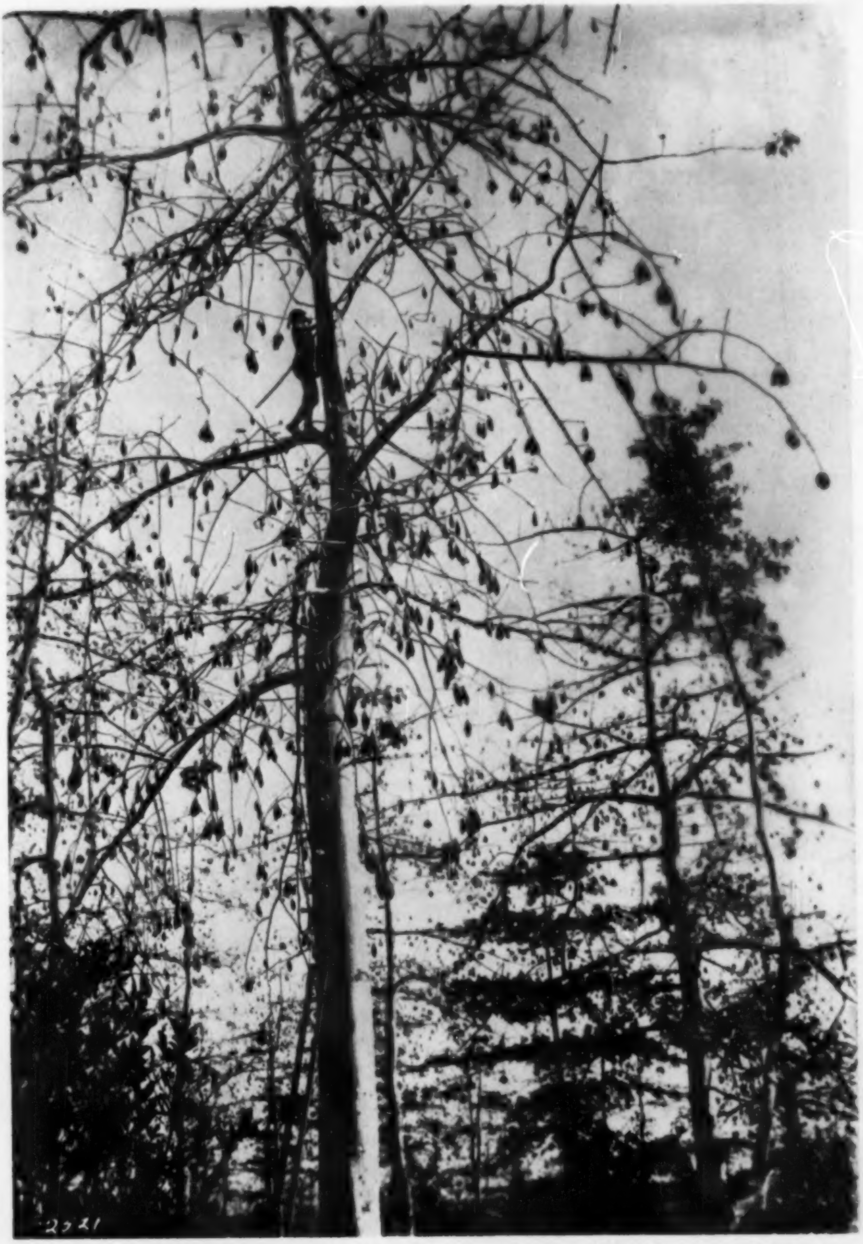


FIG. 10. Although a native of tropical America, the kapok tree thrives in Indonesia.

adaptable to spinning and therefore is seldom woven into cloth. The seed pod also contains small black seeds which yield an oil similar to cottonseed oil.

The tree is usually 50 to 100 feet tall with very sparse growth of branches. It requires a tropical climate with distinct wet and dry seasons, year-round warmth and a volcanic soil. While the tree is not native to Indonesia but to tropical America, Indonesia's natural conditions are ideal for its growth. The tree can be propagated by either seeds or cuttings. Cuttings are set in a nursery for a year and then transplanted at the beginning of the wet monsoon season. The first harvest is usually three years later, and full production is reached when the tree is six or seven. The pods do not ripen simultaneously, and it is necessary to have two or three harvests a year lest the pods shatter before being picked. The fiber, separated from the seed by machine, is dried in the sun and then pressed into bales for shipment.

As Table XVII shows, production in 1953 was still but a third of prewar totals. Indications are that the 1954 figures would reveal a major increase because of rehabilitation and particularly favorable conditions. About 30% of the kapok trees were cut down by the Japanese for fuel and construction purposes. The Government's Agricultural Service began a five-year program of replanting kapok trees in 1949, and the program was completed in 1955. By 1960 the full effect of the service should be felt in increased output.

TABLE XVII

INDONESIAN PRODUCTION AND EXPORT, IN METRIC TONS, OF KAPOK

Year	Estimated production	Export
1935–39	22,450	20,454
1950	5,000	7,198
1951	6,500	4,939
1952	6,600	4,974
1953	7,000	4,745
1954	....	4,834

(Metcalf and Bank of Indonesia Reports).

TABLE XVIII

INDONESIAN PRODUCTION AND EXPORTS, IN METRIC TONS, OF SPICES

Year	Black pepper	White pepper	Mace	Nutmeg	Cassia
1936	44,199	11,350	834	3,971	2,505
1950	6,313	926	457	2,689	4,849
1951	2,097	678	447	2,888	3,804
1952	4,598	2,120	555	2,387	3,183
1953	2,966	4,265	2,951 *		5,566
1955	8,000	5,000	3,800 *		....

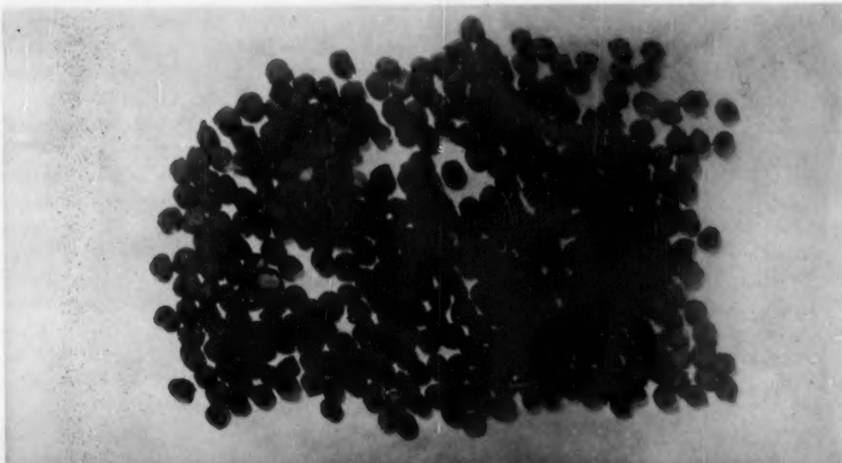
* In 1953, mace and nutmeg were computed together since they are both products of the same tree.

(Metcalf and Bank of Indonesia Reports).

Spices: Black pepper (*Piper nigrum frutescens* L.) Piperaceae; Nutmeg (*Myristica fragrans* Houtt.) Myristicaceae; Cassia (*Cinnamomum cassia* (Nees ex blume) Lauraceae.—The quest for spices was once a powerful force in world history. The search for an all-water route to the Spice Islands of the East led to the voyages of Columbus, Magellan and many other explorers, and their explorations, discoveries and conflicts mark the history of the XVI and XVII centuries. Pepper and other spices were the principal assets in Holland's former vast possessions in the East Indies.

The original use of spices was to conceal undesirable flavor and quality of food, to break the monotony of a simple diet and to act as a preservative. The early high cost was a simple application of the law of supply and demand. The Dutch East India Company, supported by the Dutch Government, did all it could to maintain its monopoly over the spice trade, but the demand for spices was so great that the industry outgrew the Dutch monopoly and spread throughout the area.

Only three of the many spices grown in the area will be discussed, namely, pepper, cassia and nutmeg.



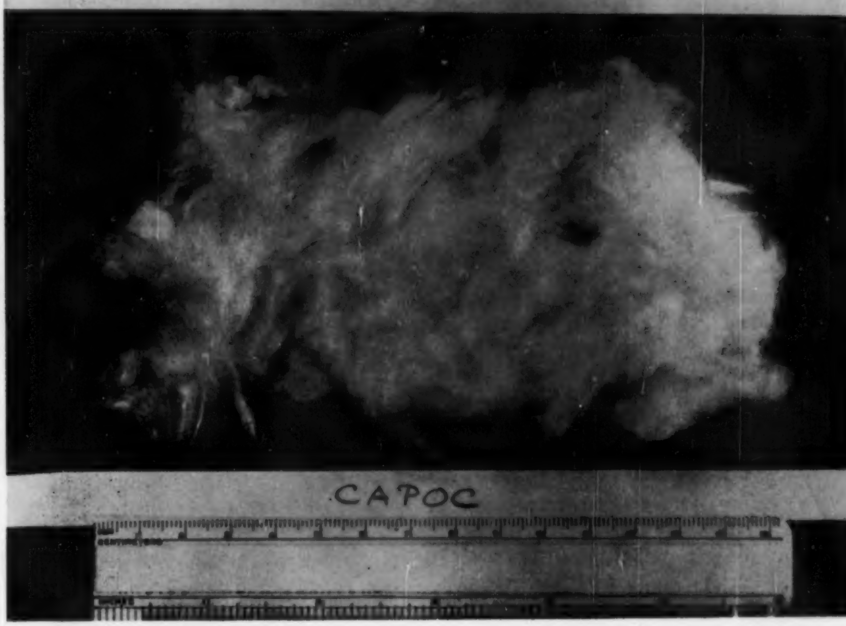


Fig. 11 (Upper). Kapok seed.
Fig. 12 (Lower). The fiber, noted for its buoyancy and absorbent qualities, which surrounds the seed within the pods.

Cassia, which comes from the bark of a tree (*Cinnamomum cassia*), can be traced back to 2700 B.C. in China. The bark is carefully peeled off when the tree reaches maturity. After a slight fermentation, the rough outer surface is scraped off and the remainder is then sun-dried.

Nutmeg (*Myristica fragrans*) is native to the Moluccas Islands and probably was first introduced into Europe about 1100. The tree yields fruit from its twenty-fifth to its sixtieth year. The fruit is collected and the pericarp removed. The inner kernel is the true nutmeg, and the reticulate covering around it is removed to yield mace, another spice of commerce.

Pepper (*Piper nigrum*)· is one of the most important spices the world has ever known. It has universal appeal and is used throughout the world. Both black and white pepper come from the same species which is now thoroughly domesticated. Black pepper is the dried, unripe fruit; white pepper is obtained from the seeds after the outer hull has been removed.

* * * * *

The export crops discussed above are the largest earners of foreign exchange at the present time. But Indonesia is a naturally rich country, and these by no means constitute the entirety of the nation's economically valuable crops. The following are some of the lesser economically important items:

Abaca (*Musa textilis* Nee.) Musaceae. —This is the world's most important cordage material. The fiber, obtained from the outer portion of the leafstalk, is light, stiff, elastic, durable, and resistant to fresh and salt water. Its major defect is that it cannot be spun.

Areca Nuts (*Areca catechu* L.) Palmaceae.—The seeds of the betel nut palm are used as a masticatory with lime, betel peppers or some other agents throughout southeast Asia. The palm is native to the Malay Peninsula.

Cacao (*Theobroma cacao* L.) Sterculiaceae.—A small tree, native to tropical America, which yields chocolate, cocoa and cocoa butter.

Copals (*Copaifera Demeusii* Harms.) Leguminosae.—Copals are resins of fossil origin. They yield a highly elastic varnish but do not adhere strongly to a surface.

Camphor (*Cinnamomum camphora* Nees & Eberm.) Lauraceae.—Camphor is one of the most important essential oils of industry. It is obtained by distilling the wood of the camphor tree, a native of Japan and China, and is used in the manufacture of cellulose and celluloid products.

Citronella (*Cymbopogon Nardus* (L.) Rendle) Gramineae.—An inexpensive essential oil obtained from a grass native to Indonesia. Besides its familiar use in insecticides, it enters perfumes and soaps.

Cotton (*Gossypium* spp.) Malvaceae. —One of the oldest fibers known to man. Archeological evidence places cotton in India before 1800 B.C. Textiles, particularly cotton, are very important in economic development, as the history of both England and Japan shows. It is a great economic advantage for a developing country to be free from the burden and financial drain of having to import raw materials for textile production. This has been a very serious failing in Indonesia but there has been a determined governmental effort to make Indonesia self-sufficient in this important area by raising cotton.

Gutta Percha (*Palaquim gutta* Burck.) Sapotaceae.—A non-elastic rubber of Malayan origin. The latex, located in the cortex, phloem and pith, deteriorates in contact with the air as a result of rapid oxidation. Because it is a poor conductor of electricity its main use is in submarine cables.

Jelutong (*Dyera costulata* (Miq.)

FIG. 13. A Javanese spice merchant with cloves, cinnamon and nutmeg.

Hook f.) Apocynaceae.—A native Malayan tree with abundant latex flow. The latex yields a poor grade of rubber. Its major use is as a substitute for chicle.

Kenaf (*Hibiscus cannabinus* L.) Malvaceae.—A fiber used as a substitute for jute and hemp in gunny sacks and cordage.

Ramie (*Boehmeria nivea* (L.) Gaud.) Urticaceae.—Ramie is an Asiatic bast fiber which has low yield but the compensating feature of more than one crop a year. It is long, durable and more lustrous than cotton. It would be a desirable textile if a simple, inexpensive process for extraction and cleaning could be developed. It is the strongest fiber known but lacks flexibility.

Rattans (*Clamus* spp.) Palmaceae.—Climbing plants, native to the East Indies, with strong, flexible, long and uniform stems suitable as splints for baskets and furniture.

Roselle (*Hibiscus Sabdariffa* L.) Malvaceae.—The soft, silky fiber is used as a substitute for jute.

Sago (*Metroxylon Sagu* Rottb.) Pal-

maceae.—The starchy pith of the sago palm, native to Malaya, is ground and mixed with water to produce a starch.

Teak (*Tectona grandis* L. f.) Verbenaceae.—A native Malayan, very durable, hard wood which does not warp, split or crack, and is decay-resistant.

* * * * *

The foregoing brief account of the major export plants of Indonesia, places us in a better position to understand and gauge their importance. Three export products—rubber, copra, and petroleum—account for 70% of all Indonesian exports Agricultural goods as a whole, comprise about 65% of the value of the country's exports. These facts make Indonesian economy extremely sensitive to any shifts in the prices paid for primary materials. A rise in export prices may cause shifts from the production of food to that of export goods; it may lead to a disequilibrium in the balance of payments and in the Government revenues; and it may have many effects upon the future course of economic development in the country.

The Government should take firm steps to diversify the kinds of goods that are being exported. This policy would free the country from its reliance on one or two primary goods, as is so often the case in underdeveloped countries, and it would also lead to an improvement in the balance of trade. To some degree this has been the policy of the Government but the scale of its efforts has been small. While taking steps toward diversification, the Government should not diversify simply for the sake of diversity. In all steps of this nature, the criteria should always be productivity and usefulness to the entire country.

In summing up this section, the export sector has a number of values to the economy. First, and something that has only been alluded to in this section, is that this sector can provide the raw materials needed to develop industries which can compete with foreign goods. Second, exports are a major source of foreign exchange earnings. Thirdly, export sector goods yield a large revenue return to the Government through export duties. Finally, this sector is a major source of employment for thousands of Indonesians and through them has a profound effect on converting a peasant barter economy into a money economy.

The Government and Development

The major efforts of the Indonesian Government have been devoted to achieving self-sufficiency in the production of food. The improved food output is a direct result of increased production and a mark of the Government's success. Few improvements in agriculture can be made by individuals working alone. Realizing this simple fact, the Government has concentrated its attention on the small holder and his problems. Research and agricultural experimentation, dissemination of new information and techniques, improvement and rehabilitation of irrigation facilities and other public works are all projects that are beyond the capabilities of individual initiative, especially in a backward country. The Government has aided the small holders in all these fields. It has established credit and lending facilities, has aided with the distribution and marketing of products through semi-public boards, and, even more important, has tried to create a climate which is favorable to individual initiative. The results have been increased food production and, at least temporarily, self-sufficiency.

One of the stated purposes of the Government is to raise the living standards throughout the country. This can be done only if total productivity increases more rapidly that population. One of the major problems confronting the

Government is that the standard of living is so low that it is difficult for the small holder to save. The per capita output is low because of the poor equipment and the obsolete methods being used. The tendency of most producers to consume what they produce is as much of an economic drag as a ship attempting to sail with its anchor still in the water. Because of their low standards and their high propensity to consume, small holders seldom have enough money to create an effective economic demand. As a result, it is usually unprofitable for foreign capital to invest in the country unless it is oriented toward external foreign markets rather than to the domestic market. The classic examples are the extractive industries—petroleum and metal ores—which are directed to the markets of Europe and America, not to the small Indonesian consumers.

If the hope for foreign investment is slim, the only alternative is investment by domestic capital. The riddle is: where is the capital to be found? The individual holder has little of it, but a cooperative movement might be a part of an answer. The newly developing rural landlords have not yet exhibited any inclination to invest productively. The entire country is plagued by an overwhelming desire for western consumption goods. If this desire is allowed free play, the development of Indonesia will be set back. A country can develop only if it saves, and it can save only if it consumes less than it produces. It must sacrifice present consumption for future returns on investments. If this cannot be done voluntarily, the Government should step in and force the country to save through taxation, inflation or some other means.

Another problem facing a developing nation is how to mobilize the domestic savings and then convert the savings into productive investments. In an agricultural country, this is very difficult because of the many types of social overhead projects, such as roads, dams and research, which must be undertaken. Social overhead projects are generally beyond the scope of individual enterprise, as was pointed out before. Therefore, in many cases the Government must be the motive force in the mobilizing of savings and channelizing of investments. Fortunately this country does not face the ideological conflict of private versus public enterprise. There seems to be agreement among most people of the land that at the present stage of their economic development, projects of this size and complexity are beyond the scope of private initiative and must be pursued by the Government if they are to be carried out at all.

Balanced development of industry and agriculture is the philosophy which the Indonesian government is following. The new five-year plan (1954–59) prepared by the State Planning Bureau is tentatively broken down in the following way: 13% for agriculture, transmigration and social projects; 25% for industry and mining; 25% for irrigation and multipurpose projects; 25% for transportation, communication and roads; and 12% for education and health [9]. It is safe to say that the projects for irrigation, health, education, transportation and so on will bring many benefits to the rural sector of the population indirectly. But there is general agreement that the two sectors of the economy, namely, agriculture and industry, must go hand in hand, each preparing the other for the next step, each complementing the other's progress. As one Indonesian economist and past minister of finance points out:

> The often assumed controversy of agriculture versus industry does not appear to

[9] New York Times, March 17, 1955.

> have any great relevance in light of the social and economic environment of many Asian countries. Improvement in agriculture and development of industry should go hand in hand where population is large in relation to arable land and where population pressures are a fundamental cause of under employment in rural areas. Agricultural progress can gain momentum only by developing manufacturing industries which can absorb the surplus population of agriculture (46).

The question of surplus agricultural population, previously by-passed, must be brought up at this point. One of the striking features of Indonesia is that almost 80% of the 80 million people are connected with agriculture directly or indirectly. The zero and negative marginal productivity of this excess labor could be raised by transferring the disguised unemployed from the land to some more productive employment. Some of the pressure might be relieved by the Government's transmigration policy. But labor has never been noted as being a fluid factor of production. Not only must the peasants' natural attachment to the land be overcome, but the costs of moving them to occupations apart from the land must be met. Even then the transfer is worthwhile only if this labor is utilized in some way that yields a higher productivity for their labor than if they remained on the land. These people will not move from the land unless they are offered an inducement greater than they could possibly obtain by remaining stagnant. Many writers have pointed out that the level of agricultural production could be increased by removal of this labor from the land. Others have noted the costs that would be attached to large scale population movement. Some have also realized that this labor has a great potential for use in economic development. If this labor could be used on public welfare and social overhead projects, it could create the type of public capital so important to development at a small cost to the country (37).

Another important step toward economic development, and one that was pointed out earlier, is the advantage of freedom from extreme dependence on one or two export crops. Under-developed countries are dependent upon world trade because they are incapable of producing the range of goods they need to be self-sufficient. They also tend to rely on foreign trade to finance and implement their development programs. All of these uses of foreign trade are to the advantage of the under-developed country. But in gaining the advantages of foreign trade, they must attempt to minimize its harmful effects, namely, the extreme fluctuations which world price and demand shifts subject them to, and which are amplified by the internal monetary and fiscal policies of the country. Indonesia has taken steps to diversify her exports, and this has helped the stability of the infant nation. If the economy could develop domestic industries which would produce and domestically process the primary goods grown in the country, it would be a major step on the road to development. Development of these industries would stress native Indonesian enterprises rather than foreign enterprises which tend to withdraw profits from the country. Such crops as sugar, oil palm and copra could all be processed internally without crushing initial capital investments. Processed goods not only claim higher prices on the world market but also could be used internally to develop still other domestic industries. Such development would also result in a savings in foreign exchange credits. It would avoid the loss of money that ensues when raw materials are exported only to be later imported as processed goods at a higher price and at a net loss in foreign exchange.

Conclusions and Generalizations

In many respects Indonesia can be thought of as a typically under-developed country of southeast Asia. All regions of that area are faced with the same problem of how to make their food supply meet the growing demand caused by an increasing population. However, not all the countries have the natural endowments that mark Indonesian agriculture. In most of these countries, not only must the supply of food be increased, but the entire national product must be raised if the present level of income and consumption is to be maintained. This is no simple task for a nation with a low per capita income and a high propensity to consume. It is very questionable that the governments of the countries will prove strong enough and stable enough to pursue a policy that will keep the level of consumption below what the desired level would be, and be able, at the same time, to direct the savings of the country into productive enterprises while still maintaining a democratic character.

All the countries in the area are faced with the problem of disguised agricultural unemployment. Methods of reducing this labor surplus face many problems, but there is little doubt that there would be no loss of production if the surplus labor were eventually removed from the land. In some countries the sociological and cultural factors present make the transfer of people from the land to other employments difficult; in other cases, there is a lack of necessary knowledge. In all instances there is a lack of money which is needed, at least initially, to get this labor into some other, more profitable, pursuit. As noted with respect to Indonesia, not only must these people be offered the equivalent of what they have been getting, but an added inducement as well. A form of relief project is not the answer to this problem. The workers must feel that they are doing something productive, something of value to themselves and to others. The value of maintaining human dignity may extend well beyond the comprehension of an economist looking at a backward country as something to be industrialized and developed.

Generally, all the countries in the area are primary producing countries. All are dependent on one or two primary export goods. As a result, they are all closely tied to the world market and its conditions at any particular time. All the countries tend to be unstable over the duration of the business cycle, and, as was pointed out for Indonesia, instability seldom promotes economic development. These countries have all shown the tendency to dissipate the advantages of good times and to suffer the miseries of bad times. The proposed remedies of diversification based on the test of productivity and the development of domestic processing industries are simply a start in the right direction. This has been shown in Indonesia and in other countries in the area. These are steps which should be pursued with great vigor and enterprise by the countries in the area.

The question of whether economic development will be best advanced by concentrating on agricultural progress, industrial development or a balanced development of both sectors is a decision each country will have to make on the basis of its own economic, social, natural and political foundations. Whatever their decisions are, all the countries in this area will be agricultural countries and primary producers for many years to come. Realization of this fact and an ability to put their comparative advantage to the best possible use will pay rewarding dividends. Despite much talk about the backwardness of primary pro-

ducing countries, there is no stigma attached to the economic fact of being a primary producer. Hard work, careful planning, entrepreneurship and a desire to improve can lead to significant economic importance in the world market. It goes without saying that a primary producing nation with these qualities is well on the way to creating a solid groundwork on which to build future economic development.

Finally, the benefits which agriculture is capable of bestowing can be had by all these countries. The agricultural sector can provide the raw materials needed for the development of import-competing industries; it can be used to feed the expanding population; it serves as a major employer of the nation's labor force; it provides the country with a major source of foreign exchange earnings; and it contributes a large percentage of the revenues of Government.

Truly, agriculture is the base from which future development arises.

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Utilization Abstracts

Potato Starch. Potato-starch production in the famed potato-growing Aroostook County area of Maine fell from a high of some 48,000 tons in 1950 to a low of 3,000 tons the next year and then rose to 35,000 tons in the 1955–56 season. This great variation, characteristic of the industry, is a result of the industry's being geared to the availability of off-grade and surplus potatoes instead of being controlled by the demand for the product. At present there are 22 starch-producing factories in the State, which last year ground nearly four and one-half million barrels of potatoes into starch.

Until ten years ago, most of Maine potato starch was utilized as sizing in the textile industry. Today the paper industry takes 60%, also for sizing; the textile industry, 30%; and various other industries consume the remainder. (Anon., *Chemurgic Digest 16(1): 3. 1957*).

Steroids. This group of compounds, found in a variety of plants, has been acquiring greater and greater importance in recent years as the source of raw materials that can be converted into valuable hormone-like drugs. In 1955 Dr. D. S. Correll and Dr. H. S. Gentry, both of whom have been contributors to ECONOMIC BOTANY, called attention to the Mexican yam, *Dioscorea spiculiflora,* and from the tuberous roots of these yams, two steroids, possibly convertible into cortisone, have been isolated and named " correlogenin " and " gentrogenin " after the two explorers. These two steroids are superior, for such conversion, to those in previously known species of yam in Mexico.

Most recent of the possibly valuable steroids obtained from plants is produced in the leaves of lechuguilla (*Agave lecheguilla*), a weedy plant growing over millions of acres along the Rio Grande, in the Big Bend area of Texas, and elsewhere in the American Southwest. In Mexico the plants have long constituted an important source of fiber. The steroid obtainable from these plants and also convertible into cortisone has been named " smilagenin ", and cortisone-like compounds prepared from it appear to have fewer undesirable side effects as compared with other preparations of this category. (Anon., *Chemurgic Digest 16(1): 7. 1957*).

Gum Tragacanth in Iran

Several species of the genus Astragalus, growing wild in Iran, Iraq, Turkey, Afghanistan and adjacent Russia are the commercial sources of this exudate, obtained by tapping the branches or roots. Its hydrophilic and colloidal properties are of value in the manufacture of ice cream, liquors, lotions, sizings and other industrial products.

HOWARD SCOTT GENTRY *

Introduction

In Iran gum tragacanth plants have never been cultivated in any way, only exploited in the wild according to the circumstances of market and the country inhabitants. Until recently they were given no particular attention as a continuing asset, but a national law or regulation now prohibits destruction of any gum tragacanth plant. However, at least some of the species are still used by the tribal people for badly needed firewood, and extensive stands of the larger highland shrubs are reported to have been destroyed in recent times for this purpose. Uses of the gums have been increasing in recent years, and higher prices have failed to increase supply. The growth of the industry appears, therefore, to depend upon conservation of existing stands and their increase. Also, the question of cultivation appears to be at hand.

The area of gum tragacanth in Iran has an arid temperate climate of the Mediterranean type, or with winter-spring precipitation and rainless summers. Annual average precipitation ranges from about five to 20 inches, part of which falls as snow, increasingly so in the higher elevations. Frost is of annual occurrence through the area. It is light and of low intensity in southern regions, as about Shiraz and Bam. The frosts are heavy and enduring in the high mountain elevations and may reach as low as 0° F. The growing season of the southern regions and lower elevations begins with the first fall or winter rains and continues according to temperature and moisture until early summer, when soil moisture is virtually exhausted. In higher elevations and northward the growing season is much shorter, following snow melt and continuing until midsummer.

In Iran the plants occupy arid and semi-arid highland slopes between 4,000- and 10,000-feet elevations. They are partial to the limy well-drained slopes and footplains of the mountains, frequently appearing most at home on rocky soils, all of which belong to the category of gray earths. The better producers of gum tragacanth appear to be the small, desert, cushion-type bushlets, only a few inches tall and low-spreading, in the lower elevations between 4,000 and 7,000 feet. The larger species, forming thick-branched shrubs, three to six feet tall, are generally restricted to elevations above 7,500 feet and produce lower grades of gum. Doubtless, there are exceptions to this, but such is the general case for the area visited by the author in 1955, namely, the Zagros Mountains from Shiraz to Tabriz, and the adjacent

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slopes of the El Borj Range. The dry summer climate is important to the production of gum, and rains are reported to curtail harvest.

The Plants

Gum tragacanth plants are perennial legumes, all belonging to the genus *Astragalus*, section Tragacantha, characterized by spine-tipped leaf rachises; sessile or subsessile flowers, glomerate in the axils of the leaves; and one-seeded pods enclosed in hairy persistent calyces. The inflorescence is conspicuously white hairy, in some species giving the effect of a cottony ball investing the distal part of the branch (Fig. 7). From this appearance come such native names as " panbeh " and " pachmach ", meaning " cotton " or " cotton-like ". The midribs of the leaves form a spiny protective armature for the plants, both during the short term they bear leaflets and for many years thereafter. As they lose their green color and turn yellowish to brownish, they apparently perform but little physiological function after the first season of growth. The stipules are enlarged, forming wings at the base of the petiole, clasping the stem and flowers.

The better gum plants are small, low, bushy perennials, frequently of cushion-like form (Figs. 1, 8, 9). They seldom reach 30 cm. in height and frequently are only eight to ten cm. tall. They have relatively large tap roots, and it is these which are tapped for gum (Fig. 3). A few of the species form erect bushes or shrubs, the branches of which are tapped for gum, but all of those observed by the author in Persia yield inferior grades of gum. The largest are reported to reach two meters in height. Plants one and one-half meters in height, with thick wide-spreading branches, were observed in the Zagros Mountains.

Although the above-listed characters distinguish gum tragacanth plants botanically, their most remarkable feature is a central gum cylinder. This appears most highly developed in the roots of the smaller species, e.g., *Astragalus gossypinus* and *A. echidnaeformis*, the mature tops of which can be covered by an ordinary hat (Fig. 8). A longitudinal section of a mature root discloses the central cylinder to be completely filled with an opaque gel-like substance without apparent cell structure or pith. The anatomy of tragacanth stem was examined as early as 1857 by von Mohl (2) who found that the pith and medullary rays of the central cylinder metamorphose into the undifferentiated material composing the central uniform mass of gum. Presumably there is a similar ontogeny in the root. The gum cylinder is contained by the woody cylinder with annular growth and with numerous conspicuous medullary rays radiating out from the central cylinder. These also are turgid with gum during the dry summer season. The diameter of the gum cylinder varies a great deal among species and to a less extent between individuals within a species. In non-commercial Tragacantha it is usually only one or, at most, two millimeters in diameter, while in the smaller productive desert plants it is relatively very large, the diameter of the gum cylinder near the root apex measuring as much as eight to ten millimeters or nearly half the total diameter of the root. These plants are true xerophytes with the enlarged gum cylinders appearing as nutrient and moisture storage organs, as is common in many forms of other xerophytes in all arid climates with long dry seasons.

A good gum-producing plant can be determined by cutting the tap root and inspecting the gum cylinder, a procedure which should be useful in selective breeding or seed collection. In some species the gum cylinder is smooth and clean-sided, as in *Astragalus gossypinus;* in others it contains ragged fibers which

may be forced out with the gum, making it difficult to pull off the dried exudate.

The gum is contained in the cylinder at high pressure, as is easily demonstrated during summer by cutting a section of root or stem. The gum will exude from both cut ends, but mainly from the upper. The writer has observed the exudate to reach about an inch in length in a half hour or so. This exudation was also observed and reported by Hanbury (2). The osmotic pressure of this secretion must be very high and may account for some of the coloring and impurities in the exudates, as its contact with cut tissues during extrusion indicates imbibition of cell sap from phloem, cambium or bark. The large gum cylinder of Tragacantha explains why the small plants are capable of yielding amounts of gum quite over-proportionate to their size when compared to other gum producers. With few exceptions, as in *Sterculia urens*, which contains karaya gum in the central pith as well as in other tissues, gum exudates generally originate from bark and phloem.

Generally there are two types of gum produced by two groups of plants: the small gray bushes, " panbeh " or " ghavan panbeh "; and the yellow bushes, " ghavan zardeh " or " ghineh zard ". The gray bushes yield the sweeter, clearer, better grades of gum, " maftuli ", while the yellow bushes yield the yellowish bitter grades, " kharmoni ". The yellow appearance of the latter plants is given by the russet or yellow color of the broad, stem-clasping, persistent stipules. The gray plants are found through the lower elevations, between 4,000 and 7,000 feet, and are sparsely scattered xerophytes, while the yellow bushes may become abundant through the higher elevations between 6,500 and 10,500 feet (Fig. 2). Some of the latter species may reach two meters in stature and are truly shrubs. Demarcation between these two groups is not sharp, for some of the gray plants show yellow stipules, and these or others may yield gums of both ribbon and flake grades. Likewise, some of the yellow species were found to produce ribbon grades 4 and 5. On the whole, however, the distinction is valid and useful.

Nine of the following species are here first reported to yield gum tragacanth, making a total of 23 species now known to produce the gum. Apparently many other species are still to be identified as gum plants, since the Section Tragacantha in Boissier's flora (1) includes 156 species, while that of Parsa (5) lists 104 species, many of which are additions to what was known in Boissier's time. They constitute a very rich aggregate for experimental investigations.

Acknowledgment of the generous assistance of Prof. A. Parsa of Tehran is to be made for his identification of most of the species here listed.

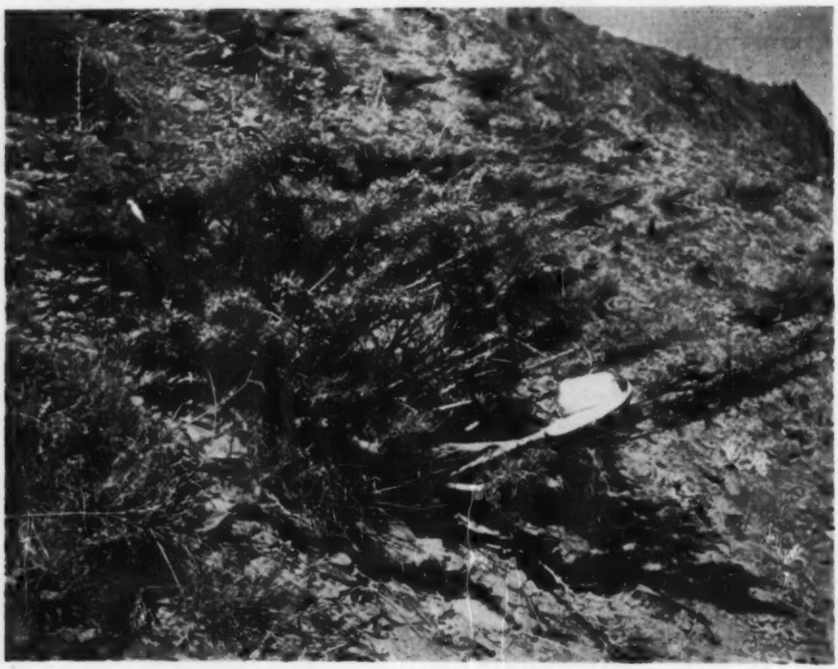
Astragalus adscendens Boiss. & Haussk. " manna "

Spreading shrub, 1–1.5 m. tall, with rather thick, numerous, widespreading, decumbent to ascending stems, forming a flat-topped crown, bearing grayish-green foliage on short spur-branchlets; leaflets 12–14, 6–8 mm. long, narrow, involute, bluntly mucronate; flowers lavender, many-glomerate in the axils and enclosed in the acute hyaline stipules; latter August and September (Fig. 4).

Calcareous rocky slopes of the central Zagros Range from Arak Province

FIG. 1 (Upper). The cushion form of vegetation in the Zagros highlands west of Abadeh, Semiron Province. Among the cushion plants are *Astragalus senganensis*. The shrub in background is *A. myriacanthus*.

FIG. 2 (Lower). At 9,500 feet elevation in Azerbaijan with Kuhe Sahand in background. The car is surrounded by a yellow bush type of gum tragacanth, *Astragalus* sp.



northwest through Luristan and about Kermanshah, from 8,500 to 10,000 feet elevations. Gentry *s.n.*, ca. 10 km. south of Khonsur, Arak Province.

Gum type-Flake grades obtained by incising the branches. This was one of the first tragacanth species reported botanically by Haussknech in the latter part of the last century.

It also produces a Persian manna, finding a ready market in Isfahan and other towns, where it is made into candy or confection, some of which appears to be exported. The product is produced as a sugar exudate from the leaves during the fall when humidity conditions are favorable. At that season the gatherers, equipped with a stick and light white cloth, go out among the plants. Holding the cloth under the exuding branches, they strike the branches with the stick, and the dry finely granular sugar falls upon the cloth. This sugar exudate from the leaves is not to be confused with the gum, which was not regarded by the author's informants as edible. The sugar exudate is not a result of insect punctures as has been reported for *Tamarix mannifera*.

Astragalus brachycentrus Fisch.
" ghineh zard "

Low spreading bush with yellow branches and crown looser than cushion type, 25–40 cm. tall; leaflets small, 4–5 mm., numerous, 10–14, pale green on pale green rhachises which turn yellow in age; flowers small, rather long-deployed along the new growth; June. The species is variable with what appear to be ecotypes; the variety *koieanus* from Luristan was named by Sirjaev (5). Gum cylinder generally large but ragged with medullary tissue.

Valley and mountain slopes of the Zagros Range from Fars to Hamadan and Luristan, 6,000 to 8,000 feet elevation, where it frequents the rocky calcareous soils. Gentry Nos *14969*, *15165*, Bavanat Valley and adjacent mountain slopes, Fars Province, 7,000–8,500 feet elevations; No. *14994*, 32 km. southwest of Abadeh, Fars Province, 8,500 feet elevation; also doubtfully referred here is sterile No. *14968*, Bavanat Valley, Fars Province, 7,000–7,500 feet.

Gum type—Produces the lower grades of ribbon and better grades of flake, and is an important producer in many localities, for instance, Bavanat Valley. The larger bushes are generally cut along the base of the branches or high up on the tap root; the old split scars were frequently observed in the field. Gum samples are reported in Table III.

Astragalus cerasocrenus Bunge
" gommer "

Forms medium-sized to rather large cushion type bushes, 20–25 cm. tall and 30–50 cm. in crown diameter, with glaucous-green foliage; the 6–8 leaflets 15–20 mm. long and rather remote on a strong rhachis; flower heads elongate, large, and well below the branch tips. Roots 50–70 cm. long with gum cylinder 3–5 mm. in diameter. Varietal differences are notable in the species, and very large specimens were reported to reach as much as one meter tall and two meters broad on the moister more fertile soils of the highlands around 8,000 feet elevation (Figs. 3, 5).

Valley slopes of the Zagros Range from Fars Province to Azerbaijan; reported by Parsa (5) also from Khorasan Province to eastern Iran. Observed on the atrital alluvial and rocky slopes of

FIG. 3 (Upper). *Astragalus cerasocrenus* with the large tap root exposed. It was topped by plowing the previous year. The root was tapped three days prior to photograph and produced the white exudate.

FIG. 4 (Lower). *Astragalus adscendens* in the Zagros Mountains near Khonsur. Besides gum it produces the sugar manna of Persia.

the calcareous soils between 6,000 and 7,500 feet elevations. Gentry Nos. *15049*, 25 km. west of Shiraz, Fars Province, *15257*, *15258*, Dastanah, Charmahal Province.

Gum type—The gums are yellowish and fall in the flake grades, the earlier pickings being of better quality than later ones. On large plants the roots become thick and woody, and the tappers report that they are opened with a hammer and chisel or with a saw. Gum samples are reported in Table III.

Astragalus echidnaeformis Sirjaev
" ghavan panbeh ", " talkheh "

Small spreading bushlet, 8–12 cm. tall and 15–20 cm. broad across the crown, the branchlets yellowish; leaves 8–10, gray canescent, ovate, with pungent tips, 6–8 mm. long, the rhachis stiff and tapering from the base, forming stiff spines 25–35 cm. long; flowers pink, July. Assigned here also is a larger, more erect, variety with conspicuous yellow, more elongate, branches, collected at Musiabad. Gum cylinder large (Fig. 6).

Fars and Isfahan Provinces, 5,000 to 6,000 feet elevations, in coarse calcareous sedimentary soils. Gentry Nos. *15181*, 80–90 km. southwest of Isfahan; *15635*, Musiabad, Isfahan Province.

Gum type—Ribbon grades. One of the principal gum producers of the Isfahan area. It is particularly abundant about Musiabad, 30 to 40 miles west of Isfahan.

Astragalus elymaiticus Boiss. & Haussk.
" golpanbeh "

Forms a low spreading bushlet, 15–20 cm. tall and 20–30 cm. in crown diameter, with canescent gray foliage and a rather loose irregular crown; leaflets few, 2–3 pairs, 12–18 cm. long, the upper pair reaching beyond rhachis tip when appressed; flowers lavender or purplish. Gum cylinder 4–5 mm. in diameter and rather ragged on the walls (Fig. 7).

Valley slopes of the Zagros Range from Fars Province to Karmanshah-Hamadan area in well-drained, alluvial, calcareous soils, from 6,000 to 7,500 feet elevations. Gentry No. *15048*, 25 km. west of Shiraz, Fars Province.

Gum type—Lower grades of ribbon and higher grades of flake. It is reported as a good gum producer; much of it doubtlessly enters the gum trade, but its collection was not observed. Gum samples reported in Table III.

Astragalus geminanus Boiss. & Haussk.
" gavan zardeh "

Small, erect, rather strictly but closely branched bushlet, 20–25 cm. tall, with a yellow color given by the glabrate stipules appressed to the branches and the persistent thorny petioles; leaflets about 5 pairs, gray, ellyptic, conduplicate, 5–7 mm. long; flowers at the base of the white pubescent new growth, July. Gum cylinder large.

Reported from between Kermanshah and Sahneh by Boissier (1) and now from 80–90 km. southwest of Isfahan, Gentry No. *15182*, on limestone bajada at about 6,500 feet elevation.

Gum type—Produces low grade ribbon and good flake grades. The quantity of gum produced by these yellow bushes is somewhat greater than from the gray bushes, but the quality is generally lower. This species appears to be one of the best quality yielders among the yellow bush group.

Fig. 5 (Upper). *Astragalus cerasocrenus*, green form, with the root crown exposed, near Shiraz, Fars Province.

Fig. 6 (Lower). *Astragalus echidnaeformis* with the earth dug away from the roots, showing the exudate several days after tapping.

Astragalus globiflorus Boiss.

" golbanbeh "

Low, gray, canescent bushlet with whitish foliage, 3–4 pairs of leaflets, 12–14 mm. long; flowering heads below the new shoots of the season; therefore, flowering early. Except for the light gray foliage, appears very similar to *A. cerasocrenus* and *A. senganensis*. Gum cylinder not examined.

Given as southwest Iran by Parsa (5). Gentry No. *14995*, 32 km. southwest of Abadeh, Fars Province, 8,500 feet elevation, on limestone conglomerate.

Gum type—Stated by tappers to be of good quality; no samples obtained.

Astragalus gossypinus Fisch.

" panbeh ", " golpanbeh ", " ghavan panbeh "

This small gray bushlet has several varieties. On the dry slopes in the Isfahan district it is only 5–8 cm. tall and 15–20 cm. in crown diameter, with gray, canescent foliage; 8–12 ovate pungent leaflets, 3–5 mm. long, along the spine-pointed rhachis. The small pink flowers appear in July and are extended shortly from the cottony white, sessile calyces in wooly white heads about the ends of the short branches. The tap root is small, 1–2 cm. in diameter, 20–30 cm. long, but the gum cylinder, 5–8 mm. in diameter, is relatively very large. In the Kermanshah area, where rainfall is more, the species forms larger plants (Fig. 8).

Along the eastern slopes of the Zagros Mountains from Fars Province to Kermanshah and adjacent northeastern Iraq, where it frequents the dry, calcareous and gypsiferous, well-drained, gray earth soils between 4,000 and 7,000 feet elevations. Widely scattered and never observed in close colonies. Gentry Nos. *15268, 15269,* ca. 10 km. north of Kermanshah, Ostan 5; *15680,* ca. 35 km. east of Tehran; *15260,* Kuhe Safed near Isfahan; *s.n.*, Estavant, Fars Province.

Gum type—Produces the best or ribbon grades. One of the most important commercial species in the Isfahan and Tehran areas. It is probable that gum from this species also reaches Bagdad via the nomads from the western slopes of the Zagros.

Astragalus microcephalus Willd.

" panbeh ", " ghuchu ", " golbanbeh ", " golpachmach "

Small, low, spreading, gray-canescent bushlets, 8–12 cm. tall, 15–25 cm. broad; 8–12 leaflets, 4–6 mm. long, ovate, pungently tipped; flowers very late, not seen. Gum cylinder well developed, 6–8 mm. in diameter below the root crown. Apparently a variable species (Fig. 9).

Eastern valley slopes along the Zagros Range from Fars Province to the southern slopes of El Borj Range, fid. Parsa (5). Calcareous atrital slopes 4,000–5,500 feet. Gentry Nos. *15078,* Bajga, 15 km. east of Shiraz, Fars; *15164,* Kuhe Bavanat, Fars Province, 8,000–8,500 feet elevation.

Gum type—Ribbon grades and stated by the tappers and merchants of Shiraz to be the best produced in that region. Good clear samples were collected and weighed, Table III.

Astragalus myriacanthus Boiss.

" ghineh cheraghee "

Erect spreading shrubs, 6–14 dm. tall, with thick stems, 5–8 cm. in diameter, thick spreading gray branches, and numerous short spur branchlets with yellow scarious appressed stipules, yellow spreading thorns; the new growth white

FIG. 7 (Upper). *Astragalus elymaiticus* near Shiraz, Fars Province, with root and exudate exposed after digging. Note the ball-like cottony inflorescence at ends of the branches.

FIG. 8 (Lower). *Astragalus gossypinus* near Isfahan with spiraling exudate. This is a mature plant several years old.

pubescent with numerous small flowers in June; leaflets numerous, 16–20, and small, 3–4 mm., ovate, mucronate, gray pubescent. Colonies of these flat-topped bushes are characteristic of the highlands in many localities in the Province of Fars (Fig. 1). The branches of this and related species allegedly burn well and are used for fuel.

Boissier (1) reported this shrub from Dená in the southern mountains. It was observed frequently on excursions through Fars to Charmahal in the central Zagros at elevations between 7,500 and 10,500 feet. Gentry No. *15047*, mountain above Bajga Valley, east of Shiraz, Fars Province, on limestone.

Gum type—Produces low quality gum of flake grades from incisions made along the branches. The amounts obtained are greater than from the roots of the small gray species, but, since the value of the gum is very low, the bushes are untapped in many localities. Gum samples are reported in Table III.

Astragalus senganensis Bunge
" gommer "

Low, dense, erinaceous perennials with pale green foliage; 6–10 leaflets, 15–20 mm. long; short globose flower heads at the ends of the branches. It closely resembles *A. cerasocrenus* from which it is distinguished by the short, distal, globose flower heads (compared to non-distal, oblong flower heads) and by the stamens being attached near the base of the staminal tube (vs. attached high on staminal tube). The tappers encountered did not distinguish between the two species. The gum cylinder of the root is rather small and ragged (Fig. 1).

Mountain and valley slopes of the limestone mountains of the Zagros Range from Fars Province to " montagnes entre Teheran et Ispahan ", Parsa (5). Gentry Nos. *14970*, Bavanat Valley, Fars Province; *14993*, 32 km. southwest of Abadeh, Fars Province.

Gum type—Flake grades, and a rather low producer, Table III.

In addition to the above-listed species, observed and collected in the field as producers of gum tragacanth, the following have been reported by other authors (2, 7, 3) as yielding gum tragacanth.

A. brachycalyx Fisch., from the Anatolian slopes, including southern Kurdistan and northern Iraq. An erect shrub of the yellow group, doubtless cut along the branches and yielding flake grades, as is common in that group.

A. creticus Lam., reported as from Crete and southern Greece.

A. cylleneus Boiss. & Heldr., from the Peloponnese Islands.

A. eriostylus Boiss. & Haussk., described as a low shrub, 1 meter tall and somewhat erinaceous, from southern Iran.

A. gummifer Labill., from the Anatolian Plateau in Turkey and Armenia as a low spiny bushlet producing much of the gum in earlier times from that area.

A. heratensis Bunge, growing in the region around Herat in Afghanistan and adjacent Khorasan Province of Iran as a low cushion type of plant.

A. kurdicus Boiss., reported as from Chormuh mountain near Bushir, southern Iran.

A. leiocladus Boiss., reported from the Zagros mountains of Arak Province with decumbent branches. It is placed in the section Brachycalyx along with *A. adscendens* and *A. myriacanthus;* so it is presumably tapped along the branches and yields low grades of gum.

A. pycnocladus Boiss., Arak Province in the central Zagros. Forms a low cushion type of plant, closely related to *A. microcephalus*, and therefore is presumably tapped on the root.

A. strobiliferus Royle, described as from the Harirud valley of northwestern Afghanistan and closely related to *A. globiflorus*.

A. stromatodes Bunge, an erinaceous shrublet from the Anatolian region.

A. verus Oliv., described as from western Iran between Kermanshah and Hamadan, with 8–10 leaflets on a very short rhachis (2 cm.).

It is to be expected that several others of Tragacantha also produce the gum tragacanth of commerce. Very little botanical field work, other than collecting specimens, has ever been done with this group of plants. They are spiny and difficult to handle and to press. It is only to be expected that botanists have frequently passed them by for other easier subjects. In studying the roots in the field, the writer found that several other spiny species, but with pedunculate inflorescences, also produce gum. Samples of gum procured from some of these were pronounced by gum merchants not to be gum tragacanth, but of inferior sorts, and were known in the trade by other names, as "shadeh", "ghooreh" and "oshagh" (Fig. 11). The spiny plants having pedunculate inflorescences are therefore to be excluded from the gum tragacanth group.

FIG. 9. *Astragalus microcephalus* at Bajga, Fars Province, showing several inches of gum tragacanth from an incision made three days previous.

Gum Tragacanth in Commerce

History. It is unknown how and when man first discovered gum tragacanth, as its use predates ancient history. Speculatively, he probably used it first as food when impelled by hunger, since ants, goats, sheep and wild sheep appear to be fond of the sweeter kinds. Or he used the more bitter varieties as medicine, for sickness was an adversity that drove companions of the ill to innovation through cult and mysticism. Flückiger and Hanbury (2) were of the opinion that the gum was first used in historical times as an item collected from the bark and that only later, as demand increased, were incisions made to increase supply. It was known to the Greek physicians from the 7th to the 4th centuries B.C. Theophrastus in the 3rd century B.C. wrote that the plants producing it were native to the Peloponnesian Islands and to Crete.

By 1300 A.D. it was an article of com-

merce to Europe via the trading cities of Italy. Among early travelers from Europe to the Near East, who actually saw and reported the plants with their exudates, are Pierre Belon in 1550 and Tournefort in 1700 (6). The German botanist, Haussknecht of Weimer, visited northwestern Persia in the latter part of the 19th century, and some of Boissier's species are based on his collections. It is one of the oldest drugs in Materia Medica and has been offered in every edition of the U. S. Pharmacopoeia since 1820. A common Persian term for gum is " katira ". Some of the gum tragacanth bushes in Fars, home of the Archaemenian kings, are still called " cummer " or " gommer ". This is suggestive as the origin of our term " gum ", being traceable through French " gomme ", Latin as " gummi " or " cummi ", and Greek as " kommi ". It is about as clear as good gum itself.

Identity. Gums are defined as water-loving, or hydrophilic, colloids occurring as exudates of certain perennial plants. They are truly amorphous without melting point, freezing point, or boiling point characteristics. They are largely carbohydrates containing calcium, magnesium and potassium. Nitrogen, although it may be present, is not an essential constituent, its usual absence distinguishing them fundamentally from proteins which always contain nitrogen. Gums differ from resins in being colloidally soluble or dispersible in water but insoluble in organic solvents and drying oils; resins are insolvent in water but are soluble in drying oils and organic solvents. Gums are quite unrelated to resins in their uses as well as physically and chemically.

The great capacity of gums to absorb water, forming viscous solutions and colloidal gels, has found wide application in industry. Such colloidal solutions are known as " sols ". They have low surface tensions and act as protective colloids and stabilizing agents. Tragacanth gum consists of a soluble portion, tragacanthin, and an insoluble portion, bassorin, the latter constituting 60 to 70% of the total. Tragacanthin consists of a ring containing three molecules of glucuronic acid and one molecule of arabinose with a side chain of two molecules of arabinose. The soluble portion gives a colloidal hydrosol solution with water, while the insoluble part swells into a gel. For further chemical exposition the reader had better turn to Mantell (4). Vegetatively the tragacanth gums are unique, as they are the only commercial ones originating solely in a central gum cylinder. In commerce they rank with gum arabica in quantity and quality.

The uses of gum tragacanth are many. The sweeter, clearer, finer sorts, ribbon or " maftuli ", are employed in pharmaceutical mixtures; in liquors, to which they add smoothness or " body "; in cosmetics, as the glycine toilet creams; jellies, lotions, dental creams and many others. Confections consume much of the fine grade tragacanth, however, and the American consumer, without knowing, may take it in ice cream, candies, syrups, jellies, salad dressings, mayonnaise, pickles, sauces, chutneys, flavour emulsions and egg substitute preparations. The bitter, less clear tragacanth gums, flake or " kharmony ", are employed in dyes, paper sizings, waterproofing for fabrics, as a creaming agent for rubber latex, and so on. They have an extensive use in the textile industry as constituents for the sizing of yarns and threads, for the stiffening of felt goods, for leather dressings, and for transparent finishing of silk or rayon. There is also large application in calico printing, and much of the local consumption in Iran is by that industry. Altogether it is a multiple purpose resource for food and textile products.

Imports. United States imports of gum tragacanth during the past two decades have averaged over two million

pounds annually at an annual cost of over one and one-half million dollars. Had there not been a decline in supply, imports would have been more during the past decade. Source of imports from 1945 through 1954 is shown in Table I. Iran is our principal supplier, followed by Iraq and Turkey. Imports from India, the United Kingdom and other subsequent and continuing decrease. This appears due to limitation of the existing resource, as was pointed out by Iranian merchants. In view of the increasing use or demand and the general deterioration of the wild stands of *Astragalus* shrubs, it is very unlikely that price will lower, unless more satisfactory substitutes are found.

TABLE I. UNITED STATES IMPORTS OF GUM TRAGACANTH DURING THE LAST DECADE. NOT SHOWN AS TO SOURCE BUT INCLUDED UNDER "OTHERS" ARE TWO SUBSTANTIAL LOTS FROM LEBANON AND ONE LOT FROM SAUDI ARABIA. SOURCE, CENSUS BUREAU, UNITED STATES DEPARTMENT OF COMMERCE

Year	Iran		Iraq		Turkey	
	lbs.	*U.S. $*	*lbs.*	*U.S. $*	*lbs.*	*U.S. $*
1945	2,600,997	2,027,976	8,907	27,934	406,477	194,306
1946	3,667,393	3,305,005	42,629	56,317	4,389	7,981
1947	3,017,240	3,153,777	27,944	95,310	3,901	1,663
1948	2,600,809	2,343,079	220	308	......	......
1949	1,181,972	1,074,895	......	......	3,103	1,126
1950	2,817,455	1,889,991	2,580	4,405	1,587	980
1951	1,251,401	1,455,353	......	......	627	998
1952	2,491,652	1,921,714	......	......	......	......
1953	1,335,336	749,040	......	......	......	......
1954	1,018,460	639,644	154	349	......	......
Totals	21,982,715	17,920,830	82,434	184,623	420,084	207,054

Year	India		United Kingdom		Europe and others	
	lbs.	*U.S. $*	*lbs.*	*U.S. $*	*lbs.*	*U.S. $*
1945	......	.....	50	44	......	......
1946	123,170	73,902	......	......	......	......
1947	13,387	11,457	......	......	150	630
1948	......	.....	3,330	5,808	......	......
1949	......	.....	17,509	6,841	39,600	13,499
1950	2,325	950	48,153	41,919	25,822	23,242
1951	......	.....	6,815	2,214	9,788	19,866
1952	673	224	20,851	9,323	5,494	4,958
1953	6,335	7,825	2,800	5,905	......	......
1954	......	.....	......	......	......	......
Totals	145,890	94,358	99,508	72,054	80,854	62,195

European countries are trade detour lots which originate in Near East countries.

Figure 10 indicates the average price and quantity imported from 1931 through 1954. It is apparent that supply and price have not been closely correlative from the war years to the present, as a great increase in price was followed by only a limited increase in supply with

United States imports represent only a part of the Iranian production. Table II, prepared by American Consul John Ordway, in Isfahan, is based on Iranian customs statistics and shows total Iranian exports for nearly three years. This constitutes the bulk of Iranian production, as it is reported that relatively little is consumed locally. During this

TABLE II. IRANIAN EXPORTS OF GUM TRAGACANTH FROM MARCH, 1948, TO JANUARY, 1951 (IRANIAN CALENDAR 1327–29). SOURCE, AMERICAN CONSULAR REPORT, JOHN ORDWAY, 1951

	Country	Metric tons	Value in Rials *
March 1948 to March 1949	United Kingdom	760	35,309,000
	United States	768	32,430,000
	France	285	11,270,000
	Germany	259	8,640,000
	India	153	8,204,000
	Other countries	292	9,382,000
	1948–1949 Total	2,497	105,235,000
March 1949 to March 1950	United Kingdom	795	41,688,000
	United States	163	6,151,000
	France	546	9,710,000
	Germany	255	9,237,000
	India	106	3,984,000
	Other countries	277	13,191,000
	1949–1950 Total	2,142	83,961,000
March 1950 to Jan. 1951	United Kingdom	995	57,982,000
	United States	584	28,032,000
	France	622	20,772,000
	Germany	243	10,744,000
	India	155	6,107,000
	Netherlands	356	14,904,000
	Other countries	333	16,795,000
	1950 (10 months) Total	3,288	155,336,000

* The official exchange rate is Rials 32 equals \$1.00 but the rate of Rials 48 to \$1.00 is generally used in export transactions.

term these exports amounted to nearly seven million dollars in value, representing hard currency for Iranian commerce. The United Kingdom and the United States took about half of total Iranian exports during this period, with about 20% going to the United States. London has long been a principal center of world trade in gums.

The Industry in Iran. While in Iran the writer interviewed gum merchants in Shiraz and Isfahan, and a number of tappers and contractors elsewhere. The following is a digest of the information obtained regarding gum commerce in that country.

The commercial grades of gum tragacanth have been more or less standardized. In recent years in Iran a company has been formed to regulate exports and to preserve uniform grading and price. Tehran, Isfahan and Shiraz have been designated as the grading and exporting centers, and all gum produced must pass through the exporters in those towns. Grading is done by experts or trained youths on the basis of color and quality as it appears in the varied lots received from the collectors, with but incidental attention to specific plant origin. Certainly the commercial graders have no concept of species nor of the properties to be correlated with such. Samples collected were taken for commercial grading to one of the principal exporters of Isfahan. Single samples, consisting of the exudate from one cut on a single plant in several cases, were broken and separated into two or even three grades solely on the basis of color differences. However, some of the samples from related *Astragalus* shrubs were immediately identified as not being gum tragacanth, showing the perceptive acumen of an experienced merchant. The commercial grades with current prices per kilogram, Isfahan, as of July, 1955, were:

Ribbon or " maftuli "		
No. 1	540 rials	\$7.20
2	430	5.70
3	330	4.40
4	250	3.33
5	160	2.13
Flake or " kharmoni "		
No. 1 (26)	140 rials	\$1.87
2 (27)	120	1.60
3 (28)	75	1.00
4 (55)	55	.73
5 (31)	45	.60

No. 1 ribbon in Shiraz was quoted at 500 rials, where 550 was reported as the Tehran price for the same grade, the difference being attributed mainly to transportation costs. The same grade was reported to have sold the previous year for around 440 rials. According to these prices, it would appear that the U. S. consumer pays \$5–8 per kg. for top grade

gum tragacanth, which he consumes in ice cream, liquors, confections and other items.

Import statistics give no indication of such price ranges nor of the amounts produced of such grades. Shiraz reported that only about one percent of production in that area is of top grade, while the flake or inferior grades constituted the bulk of production. The Isfahan area produces a higher proportion of ribbon grades than does Shiraz, but flake grades are reported as constituting most of the production in that area and elsewhere in Iran. No figures are available showing the respective quantities of ribbon and flake grades produced [1].

These quotations are said to be 20 to 30% higher than in 1954. Merchants justified the prices of 1955 by the poor crop that year, which was estimated to have been only about half that of the preceding year. The light production was attributed to: (*a*) heavy floods of the previous winter which allegedly washed out many plants; (*b*) a general lack of spring rains; (*c*) scarcity of tappers who were attracted to more lucrative labor; (*d*) steady decline in the number of plants during the last 40 years as a result of burning the shrubs for fuel and of attempts to control the bug pests of *Agrostis* and *Aelia*, which over-winter in the plants. It is reported that 40,000 to 50,000 people are employed seasonally in this industry, the great majority being the village people who cut and collect the gum. One village in the prov-

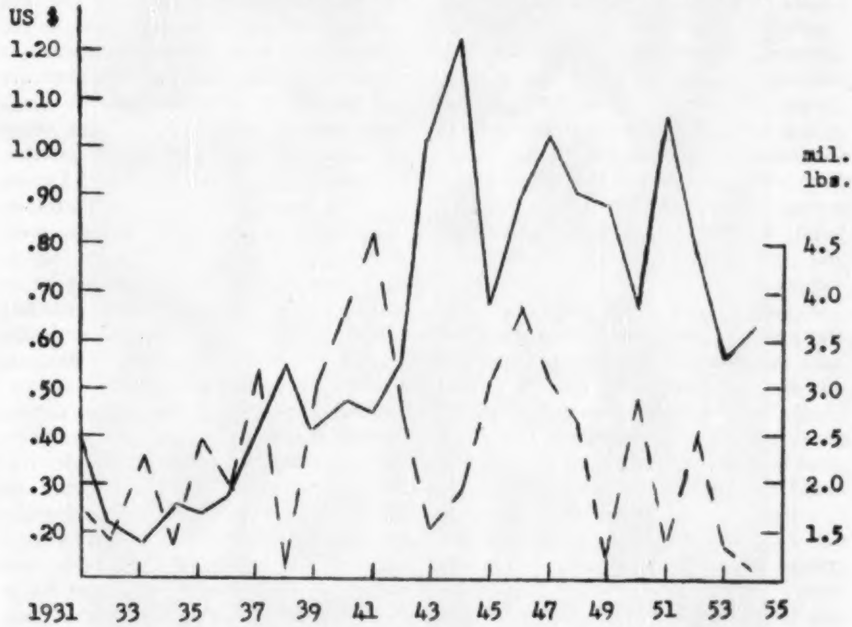


FIG. 10. United States imports of gum tragacanth from 1931 to 1955, showing wholesale price and quantity (broken line). Source, Census Bureau, U. S. Dept. of Commerce.

[1] Spot price for 1955 top grades of ribbon in New York, according to Meer Corporation, range from $2.10 to $3.50 per lb., confirming the Isfahan quotations for the same year.

ince of Charmahal supposedly marketed 2,000,000 rials worth of gum in 1954. Other villages apparently rely heavily upon this natural resource for cash. It is a valuable article in the commerce of Iran.

Collecting the gum is a seasonal vocation for nomads and peasants. Many of them gather it from tribal or village areas and sell directly to local merchants. Collection over large areas is handled by contractors who arrange rights of collection with landowners. The contractor recruits workers who tap the plants and receive pay on a weight and gum-grade basis. The contractor sells to the principal merchants of the cities. From range and village the gum is transported by hand and burros to a trucking point, whence it moves to the grading and packing cities, Shiraz, Isfahan and Tehran.

A gum tapper needs a good pair of legs and a strong back. His tools are a light maddox-like blade on a long handle and a small knife with a curved blade. When collecting he carries a bowl or a bag for the pickings. The earth must first be dug away from the tap root under the low rounded crown of thorns to a depth of four to eight inches (Figs. 6 & 7). This entails hard labor as the ground is rather hard and frequently stony. One or two cuts are then made into the upper part of the tap root, deep enough to open the gum cylinder one to two inches long. The plants are widely scattered, and not more than a few dozen are commonly found on an acre. Any given locality usually has two or three species producing different types of gum. This calls for considerable walking about between plants, both to make the initial root exposure and cut and subsequently for repeated returns to collect the exudate.

According to the collectors, the best grades of gum are those of the first three collections or those made within ten days after cutting. After the initial ten or twelve days from cutting, longer periods may ensue between collections, and the quality then deteriorates. At Bajga a tapper working a high quality species reported that others had the right to collect gum from his plants after he had made his initial first three collections. Anybody may collect it, he said. As new series of cut plants are added to the season's number, there is less and less time to revisit the older cuts, so the exudate may wait as much as a week or two before being collected. Animals are said to like the gum, so there are losses from insects, from lizards, from sheep and goats, as well as from wild gazelles, unless the plants are guarded. During the first ten or twelve days, therefore, the tapper guards his subjects well. Afterwards it apparently pays him to open new accounts by tapping other plants rather than to remain guarding the declining returns from diminishing quality and value. However, in Bavanat Valley, where different species are exploited, three weeks was the normal period between collections, but less valuable gum was being collected under different conditions of communal rights and animal interference. Tapping schedules are therefore determined partly by local customs, by the species available, and by circumstances. One tapper at Bajga was observed returning from a day's collection with about one pound of initial gum with a value of 150–175 rials, or $2.00 to $3.50, representing part time for three days. Others reported that they made up to 250–300 rials or $3.33–4.00 per day.

Trease (7) records the burning of tops at tapping time in the Shiraz area of Fars. This practice was not observed there in 1955 nor called to my attention by informers; government conservation measures may have eliminated it. About Karaj near Tehran, however, the plants were topped at tapping time and the

FIG. 11. Grades of gum tragacanth selected according to color and texture; 1, ribbon No. 1; 2, ribbon No. 2; 3, ribbon No. 3; 4, ribbon No. 4; 5, flake grade; and two other commercial gums of Iran; 6, "ghooreh"; 7, "oshagh". (Scale in centimeters).

tappers claimed that they obtained more gum by such operation. It was not observed elsewhere, but these two instances indicate a more general practice. If gum production is actually increased by topping, this would indicate a tie-in with transpiration. However, this appears to be a get-rich-quick makeshift, shortening the harvest season, as topping destroys the manufacturing part of the plant.

Tapping starts in June, and the plants are said to continue to extrude gum until the rains of autumn or for about 100 days or over. If rain falls during the tapping period, it is said to spoil the gum by mixing dirt into it, the plant no longer exudes gum, and the production season is at an end. Therefore, dry summer climates are best suited for gum production. Most of the gum is extruded at night, according to the tappers, and such seems to be true so far as the present authors limited observations are concerned. Presumably exudation pressure increases as transpiration decreases. The plant appears to manufacture gum more or less as it is forced out, the wavy pattern on the exudate reflecting alternation of pressure and its release. It may therefore be regarded as a chemical plant in continuous operation. Table III summarizes the collections of gum samples obtained by the writer in Iran during the early summer of 1955.

Factors Affecting Yield

The quantity and quality of gum yield appear to be affected by many factors. These are outlined below on the basis of field observations. The magnitude of many of them can be determined only by special investigations, and some would require physiological studies under laboratory conditions.

Natural Factors

Kind of plant. The samples collected show that different species and varieties produce various kinds of gum in amounts that differ significantly according to specific identity of the plants. Several species produce top grades of gum, as *A. gossypinus* and *A. microcephalus*, while other species and varieties produce inferior grades.

Exudation deterioration. In general, the gum from any one plant deteriorates in quality as tapping proceeds. The first collections are the best; later collections are assigned to lower grades. This is particularly true of high quality species where collections are made every few days. Species with inferior types of gum, as those tapped on the branches, are generally collected at intervals of weeks, and the gum-quality deterioration is not evident.

Age of plants. The foregoing sample Tables establish that the larger older plants produce greater amounts of gum. Quality according to age appears to be about the same, except in cutting tapped old pockets of gum discolored from previous wounds.

Size of gum cylinder. Generally, the larger the gum cylinder, the better and more the yield. This appeared to be true for quantity throughout all specific and subspecific categories.

Growing conditions previous to harvest. Good spring rains preceding the tapping season were stated several times to lead to good gum production. This would appear to be true on any physiological basis, as soil moisture availability is a vital factor in all plant functions.

Soil moisture at tapping time. A sudden increase in soil moisture during tapping season apparently results in marked decrease of exudation pressure, as rains are said to terminate tapping.

Air humidity at tapping time. Most exudation occurs at night when air humidity is higher than during the day. Humid air would tend to favor less rapid drying of the exudate, with consequent less plugging effect by drying gum and a generally smoother outward flow, or smoother response to pressure.

TABLE III. GUM TRAGACANTH SAMPLES TAPPED AND COLLECTED BY THE WRITER, JUNE–JULY, 1955. AMOUNTS GIVEN IN GRAMS

	Plant size or estimated age	Collected after cutting			Total	Com. grade
		3rd day	6th day	9th day		
A. microcephalus	med., 3 yrs.	1.75	0.85	0.41	3.01	ribbon
" panbeh "	small, 2 "	1.05	0.21	0.26	1.52	"
Gentry 15078	med., 4 "	2.00	0.25	0.21	2.46	"
	large, 8 "	3.70	1.21	0.71	5.62	"
	small, 3 "	1.74	0.55	0.96	3.25	"
	(average)	2.12	0.61	0.51	3.17	
			7th day			
A. microcephalus	small		1.24			flake No. 5
" ghuchu "	small		2.25			" " 2 & 4
Gentry 15164	old bush		1.77			" " 2 & 3
	medium		2.85			" " 2 & 3
	medium		5.06			" " 3
	(average)		2.63			
			6th day			
A. echidnaeformis	5 plants		unweighted			ribbon
" panbeh "						
Gentry 15181						
				12th day		
A. elymaiticus	medium		3.07	2.00	5.07	
" panbeh "	large		3.07			
Gentry 15048	medium		2.08			
	large		2.89			
	(average)		3.03			
A. cerasocrenus	gum cyl. 5-6 mm.	1.08				flake No. 1
Gentry 15258		0.50				" " "
	" " 3-4 "	0.27				" " "
		0.14				" " "
	" " 5-6 "	3.14				" " "
	(cuts poorly made account for low yields)					
A. cerasocrenus	large		5.17	3.80	8.97	
" gommer "	large		2.24	0.38	2.52	
Gentry 15049	medium		1.77			
	medium		1.09			
	small		1.46			
	large		1.37 (tapped too high)			
	small		1.32			
	(average)		2.06			
			5th day			
A. cerasocrenus			1.25			
" gommer "			1.22			
Getnry 15080			0.57			
			2.27			
			1.42			
	(average)		1.34			
			7th day			
A. senganensis	medium		2.62			flake No. 1
" gommer "	small		0.30			" " 1
Gentry 15166	medium		1.40			" " 3
	small		1.13			" " 1
	large		2.31			" " 1 & 3
	(average)		1.55			

TABLE III (*Continued*)

	Plant size or estimated age	Collected after cutting			Total	Com. grade
		3rd day	6th day	9th day		
A. brachycentrus	small		2.16			flake No. 3
"ghineh zard"	small		1.40			" " 2
Gentry 15165	medium		3.94			" " 2
	medium		1.55			" " 1 & 3
	old, gnarled		4.61			" " 1 & 3
	......		5.30			" " 2 & 3
	(average)		3.16			
			27th day total			
A. brachycentrus	medium					
"ghineh zard"	medium		21.90			flake No. 3, 4, 5
Gentry 15168	(average)		11.00			
			5th day			
A. myriacanthus	branches		2.00			flake
"ghineh cherari"	"		2.96			"
Gentry 15047	"		5.54			"
	"		3.00			"
	"		1.96			"
	(average)		3.12			
			2nd col. 6th day			
A. geminanus "zardeh" Gentry 15182	5 plants		2.84			ribbon No. 5

Air temperature at tapping time. Higher air temperatures during the day increase drying rate of the gum and apparently cause a sealing of the wound during daylight hours when exudation pressure is at minimum due in part perhaps to transpirational loss of moisture. As transpiration ceases, pressure appears to increase until it reaches a point sufficient to unseal the gum-plugged wound, when extrusion resumes.

Animal consumption. Many animals appear to eat the gum, which results in loss of product. The wild sheep of the mountains are said to uncover the roots with their hoofs and to wound the branches with their horns during their rutting season in order to obtain the gum. Aphrodisiac properties are therefore ascribed to the gum. It is more likely, however, that the exudation season of the plant happens to correspond with the rutting season of the sheep. Ants, lizards, domestic sheep and goats appear to be the only serious offenders to the tapper's efforts.

Artificial Factors

Depth and size of cut or cuts. Theoretically, tapping should be done with minimum damage to the plant and to withdraw the gum according to its rate of manufacture by the shrub. The average tapper thinks but little of the former aspect and certainly not at all of the latter. However, tappers informed me in certain cases that the branches should not be tapped or the plant would be killed. In general they make the incision which experience teaches them is necessary to open the central cylinder. Their cuts are usually longitudinal or cross-angled on root or stem, one to two inches long, and three-eighths to five-eighths of an inch deep, the depth of cut depending upon the diameter of root and

gum cylinder. An angled cut is almost certain to cut into the gum cylinder, while a vertical slit may miss it, as occurred in the author's samplings. In time new tissue growth heals the wound around a pocket of reddish old gum. It appears that a hole drilled into the cylinder would be far less damaging. The whole question of cutting technique should be explored with a series of experiments.

Location of cut or cuts on plant. In root-tapped plants the best results are obtained by cuts placed near the top of the root, one to three inches below branching level. Where tapping is done above-ground on stems and branches, the tendency is to make as many cuts as possible, as more gum is thought to be obtained in that way. This obviously causes serious injury, and it is very doubtful that more gum is obtained in that way than by a more prudent cutting pattern carried on over a longer period.

Schedule of gum collection. Removal of the gum or plug should also be done according to the rate of manufacture of gum by the plant. This can be determined only by a series of experiments. For instance, the quality of gum might be better and produced with less injurious effect to the plant by allowing the gum to remain in the wound for many days. However, this exposes the product to dirt and debris carried by wind.

Extent of injury to tops and roots. There is no question that the present method involved in digging earth away from the roots, lopping off the spiny branches that bother the digger or bending them back with his feet, results in serious injury to the plants. The earth is usually dug away from all sides of the root, during which adventitious roots are cut off or injured. Providing for deep-rooted plants by proper culture methods and perhaps preharvest pruning of tops should do much to minimize serious injury during tapping operations.

Relative cleanness of gum. This depends to a large extent upon the habits of the tapper. The tapping excavation should be made deep enough and wide enough to prevent the gum from extruding into the dirt on the sides and bottom of the hole. Adherent particles of earth and rock results in loss of gum and a reduced price. Careful tappers usually place a thorny cover over the excavated basin above the cut, thus protecting the exudate from animals and to a certain extent from rolling earth.

Potential in Cultivation

It appears strange that the source of such a valuable product as tragacanth gum has never been domesticated. Presumably the ancient methods of exploitation have never been seriously questioned. The industry has never graduated from the hunting and gathering stage, which is a fairly primitive anthropological condition. The nomads and the villagers collect the gum according to their customs, while the merchants receive it according to theirs. The pattern has not appreciably changed in over 2,000 years. The Iranian general reaction to the suggestion that the gum plants be cultivated was that there is no need to cultivate, since the plants grow wild. A few entertained the idea as a means of conserving and increasing a natural resource and livelihood. The modern occidentals, who may have considered the plant, were perhaps deterred by the low scale of labor. How could the added cost of cultivation justify itself in the fact of such low returns to labor?

Theoretically, the following considerations appear to favor domestication:

a) An acre of ground would support more than all the plants generally found on a half section of range land. Through cultivation the plants would be brought

into efficient accessibility, eliminating the footwork which consumes most of the tapper's time.

b) Planting in straight rows would make it possible to expose roots with the plow or disc and thus would save the labor of hard digging.

c) Planting on top of border would lengthen the roots, thereby increasing cylinder volume and yield, and result in much less injury to roots during exposure of them for tapping.

d) Tapping the roots in precise row planting could be done mechanically, or at least with semi-automatic and precise tools.

e) Collection of the gum could also be done on a partly or wholly mechanical basis.

f) Culture and selection of the better varieties would in time mean the maintenance of plants with yields far greater than the present field average of abused and ordinary individuals.

g) The xerophytic and cold-hardy nature of the plants makes them good prospects for relatively non-productive lands in arid and semi-arid climates of the Mediterranean type.

So far as known, the figures in Table III are the only data composed on the amounts of gum produced by tragacanth plants. The following estimate of gum yield is made as a first tentative appraisal.

The weighed samples of *A. microcephalus* at Bajga are the most complete available for any of the species. It is one of the good producers of high quality gum. Moreover, digging and cutting were done by an experienced tapper. After initial release of gum by tapping, gum production by the plant continues at a certain rate. The daily rate can be approximately computed in this case from Table III by adding the average weights of the second and third collections and dividing by the number of days: 1.11 grams by 6, or 0.14 g. per day. Multiplying this daily production rate by the number of days in the tapping season (100) indicates 14.0 g., plus the 2.12 g. of the initial collections, or 16.12 g. as total for the season per plant. The tapper's opinion, incidentally, for the Bajga plants was that they would yield about ten times the amount of the first three lots, or about 30 grams per plant for the season.

A total of 15 grams per plant for the season is here employed in the conservative interests of this estimate. Twenty percent of this is rated as top grades, ribbon Nos. 1 and 2, while 80% is assigned to lower grades of ribbon, the current respective prices of which are about \$7.00 and \$3.50 per kg. respectively.

Close spacing is accepted as suitable to accommodate the small plants of *A. microcephalus*. If larger spacing should be required, bigger plants with greater yields per plant would result, with but minor readjustment in the calculated yield.

The yield values are for one season only, and apparently should be multiplied by three or four to complete estimate of total return from one planting carried for eight to ten years. The plants are said to be tapped at two years of age and every other year thereafter for six to eight years, the total number

TABLE IV. ESTIMATE OF YIELD AND VALUE FOR ONE ACRE OF *Astragalus microcephalus* GUM FOR ONE SEASON. BASED ON YIELD DATA AND CURRENT MARKET PRICES

Spacing	Plants/acre	Yield, kg. @ 15 g./pl.	20% @ \$7.00/kg.	80% @ \$3.50/kg.	Yield value
4′ × 1′	10,000	150	\$210.00	\$420.00	\$630.00
3.5′ × 1.5′	8,400	126	175.00	350.00	525.00

of tappings on one plant being three or four. This indicates that the plants live for nine to ten years, and would gross **$2,000** to **$2,400** per acre.

The problems of cultivation and harvest do not appear so formidable as the question of the ability of the plants to grow in cultivation. Mechanics of cultivation are being handled with increasing skill for many distinct kinds of cultivates and their products. But the reactions of the tragacanth wildlings to cultivated soils and microclimates are quite unknown. How will the seed germinate? What diseases will affect them? Are bacteria necessary to their growth, and if so, what are they? Test plantings in various environments would be the first step towards making cultivates of these variable and interesting plants.

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Utilization Abstract

Pine-gum Products. At the U. S. Department of Agriculture's Naval Stores Research Station, Olustee, Florida, " scientists have developed from crude pine gum a chemical, maleo-pimaric acid, which has industrial application in printers' inks, paper sizing, alkyd resins, and photographic chemicals. From turpentine, they have prepared many important esters, including several of the esters of pinic acid. These have been shown to be excellent as lubricants for engines of jet aircraft, and as plasticizers—additives that can give plastics such desirable characteristics as low temperature flexibility, durability, and permanence. Another of their turpentine preparations, pinane hydroperoxide, is useful as a catalyst in the production of cold rubber. Addition of metals, such as lead and magnesium, to aldehyde-modified rosin has resulted in improved metal resinates that are valuable as paint driers ".

" Now, the Naval Stores Research Station announces the discovery of a new acid in rosin. This acid, named ' palustric ' for the longleaf pine—*Pinus palustris*—from which it was first identified, offers promise of greatly extending the usefulness of rosin ". Although this acid is a major constituent of pine gum (10%) and of rosin (20%), it was not previously discovered in the century of research on the composition of rosin because it is very difficult to obtain it in a crystalline condition. This acid has already proved useful in the preparation of paper sizing. (Anon., *Chemurgic Digest 15(10): 4. 1956*).

Garden Sage

Southern Europe, especially the part of Yugoslavia known as Dalmatia, has long been the principal source of this condiment, so popular in American culinary art. Commercial cultivation of the herb in the United States has been meagre, and supplies of true sage (Salvia officinalis) have been augmented by many adulterants, especially Greek sage (Salvia triloba) also from Mediterranean countries.

WARREN I. HANSON * AND GEORGE M. HOCKING **

Common sage of the garden has a history that dates back clearly to medieval times. It was probably used in Roman times and even earlier (27). Walafrid Strabo of Suabia (807–849), Abbott of Riechenau (near Constance, Switzerland), the famous botanist-physician and biographer of Charlemagne, composed one of the first known books on gardening, his "Hortulus". The 444 verses in it contain a description of each plant then commonly grown in herb gardens, including "Sage" (27, 30).

In the Middle Ages sage often was mentioned by various writers. The plant and its uses occur frequently in nearly all the early botanies. Sage was in American gardens as early as 1806 and probably before that. Six varieties were mentioned by Berg in 1863, and all of these were spoken of earlier by Monroe in 1778 (25).

Sage has been most widely cultivated as a spice plant for the last three centuries on account of its aromatic odor and unique bitter pungent taste. An infusion of the plant, sage-tea, was drunk in England before the advent of Chinese beverage tea (27).

Much ancient lore and many legends and superstitions are connected with sage. An old English proverb states: "He that would live for aye [ever] must eat sage in May" (13). "How can a man die who grows sage?" was another old European adage (11). The gardens of most European villages, both ancient and modern, have been filled with its spicy aroma. As one looked over the typical European household garden, it was thought that he could detect the state of the household by the condition of the sage growing there. The sensitive herb was conceived to follow the fortunes of the family in some mystic manner, dwindling when evil days fell to its grower, and flourishing when all was well. It is not surprising, then, that in centuries past, herbs were reputed to chase away melancholy thoughts.

In our grandmother's day, sage and most other seasonings were grown in, gathered and stored from the family's own gardens. Today's generation depends mostly on buying the herb from stores or pedlars. Yet it has retained its popularity, for sage is said to be the most popular cooking herb in America today (1).

Geographic Source

Common or garden sage is a native of the Mediterranean region, but many of the approximately 550 species in its genus, *Salvia*, are native to the southwestern United States and Mexico. According to Carl Epling, the chief author-

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ity on Labiatae, the sub-genus of which it is a member (Calosphace) is entirely American and originated in the highlands of central Mexico and Central America (6).

Garden sage is also known as true sage, meadow sage (but to be distinguished from the other species, *Salvia pratensis,* more properly so-called), red sage (term used in England; refers to the occasional color of the leaves), shop sage and as Dalmatian sage, because of its geographic origin.

Previous to 1940, the United States imported annually about 1.5 million pounds of sage, mostly as dried leaves, from Yugoslavia, especially that area formerly known as Dalmatia, and from other southern European countries. However, sage is cultivated elsewhere, especially in France, Italy, Germany, England, Malta, Crete, Greece, Israel, Argentina, Mexico, Canada, and the U. S. A. The sage imported into this country, pre-war, was quoted at a wholesale price of less than ten cents per pound (4). During and since World War II, sage has been sold on the wholesale market at 60¢ per pound (26).

During the World War II period, when our foreign supply from Europe was cut off, various importers became interested in promoting the growing of sage in this country to take the place of importations. After some early successful cultivation [1] interest in domestic production of the herb increased rapidly. High prices, due to the domestic shortage, constituted a considerable inducement to farmers to grow the crop. Some acreage around El Cajon, California, was devoted to sage during the War period and later. Experimental cultivation has been conducted in Washington State and elsewhere.

Lack of seeds and plants as a result of curtailed imports retarded the expansion of acreage. Now that importations are freer, with a full return of Dalmatian and other European types to the market, American interest in, and growth of, this herb have decreased. In 1950, 2,476,083 pounds came in.

Much of the Dalmatian sage imported through Trieste from Yugoslavia has been from cultivated plants; however, it is said that the wild Dalmatian product is preferred.

Morphology

Garden sage (*Salvia officinalis* Linné) is a two-foot tall, much branched, stiff, upright, long-lived sub-shrub. It has slender, grayish-green, long-petioled leaves, pebbly to the touch; and pale blue, streaked flowers in spikes at the extremities of the branches. The plant blossoms in early summer.

All sages have characteristically four-sided square stems, flowers in whorls, with a two-lipped calyx and two-lipped corolla. The stamens are inserted in the throat of the corolla with only the lower pair fertile and the upper pair either rudimentary or lacking. The shape of the lower lip is a specific determining factor. The pollinating mechanism of *Salvia* species has long been of interest to naturalists. Bright yellow color is missing from sage flowers, but reds and blues are frequently brilliant. Almost all of the sages have a strong aroma. The flavor of garden sage is characteristically aromatic, bitter and slightly astringent.

Histology

The dorsi-ventral lamina of *Salvia officinalis* exhibits the following structures, passing from ventral (upper) to dorsal (lower) surface (31).

1. Upper epidermis, undulate with thick-walled, cutinized epidermal cells, which are polygonal with slightly wavy, beaded walls in vertical view. Numer-

[1] The U. S. Dept. of Agriculture reported domestic production as less than one acre in 1939.

ous non-glandular and glandular hairs emanate from this epidermis, the non-glandular type predominating; stomata are few.

2. Palisade parenchyma, consisting of one or two layers of irregularly columnar cells containing chloroplasts and a few resin masses.

3. Spongy parenchyma, a zone of three or four layers of rounded parenchyma cells, most of which contain chloroplasts with a few resin masses.

4. Lower epidermis, undulate, consisting of wavy-walled epidermal cells and numerous stomata. This epidermis is densely covered with non-glandular and glandular hairs. The non-glandular hairs are long, rather whip-shaped, uniseriate, two- to five-celled, the end portion frequently reflexed; the hairs are slightly and characteristically swollen at the partitions between cells. Some glandular hairs have a one-celled stalk and a two-celled head; others possess a two- to four-celled stalk and a one-celled head; and still others display an eight-celled glandular head and no stalk (16, 31).

The midrib shows from one to five layers of collenchyma beneath each epidermis and a concave-convex group of open collateral bundles. Calcium oxalate crystals occur in parts of the leaf, contrary to Moeller's observation (16).

Growth Stimulation

In order to determine the effect of varying photoperiods on blossoming of *Salvia officinalis,* an experiment was conducted in the greenhouse of the West Tennessee Agriculture Experiment Station, Jackson, Tennessee, from January through March, 1943, and repeated in 1944. Nine plants were given natural day-length, nine were given short days (nine hours by means of cages that could be darkened) and nine were given long days (18 hours of daylight supplemented with Mazda lamps) (19). It was determined that long days are conducive to developing more blossoms. When cuttings were potted and used in the trials, no blossoms were produced in the short-day treatment. Blossoms were produced in the natural length of day, but were not so numerous nor so large as those of the long-day series. Larger plants grown for several months in the greenhouse and cold-frame before the trials began exhibited a response directly proportional to the length of day. Very few blossoms were produced, and many blossom buds were aborted in the short day. In the long day, the plants bloomed profusely, and in natural length of day the amount of blossoms was intermediate.

Propagation

Garden sage is grown from either seeds or cuttings. Plants produced from seed vary a good deal in width of leaves and general vigor. Therefore, starting sage from seed is an unsatisfactory method of propagating except to obtain the desirable plants to select from. Seeds as a rule do not germinate well, and poor stands are usually the results. It is essential that stock plants with heavy thick leaves be selected and that the plants display robust growth. Seed planting is carried out in early spring.

If cuttings are made in January or February, the plants will be ready for the field by the time all danger of frost is past. Growth of the past season should be used, and cuttings should be made one and one-half to two inches in length. If placed in sand in a cold-frame or greenhouse, rooting will take place in four to eight weeks, depending upon the temperature maintained within the frame.

According to J. P. Overcash (19), the percentage of cuttings that form roots under ordinary propagation methods is low. In an experiment to obtain a means of increasing the number of

cuttings that form roots, four commercial plant hormone powders were used to stimulate root formation. The experiment was carried out as follows:

"Cuttings were made from old plants with desirable leaf characteristics. The cuttings were made from the last three or four inches of the stems, and all but two or four of the terminal leaves were removed. The check, or untreated, cuttings were placed in the sand propagation bed in the greenhouse without treatment. The basal ends of the cuttings which were to be treated with plant hormone powders were dipped in the dry powder; the excess powder was shaken off, and the cuttings were placed in the sand propagation bed in the greenhouse. Thirty cuttings were used in each treatment of each replication. After five weeks in the bed the cuttings were removed and the number with roots was recorded for each treatment. 'Rootone' was obtained from Merck and Company. The 'hormodin' powders were obtained from the American Chemical Paint Company" (19).

The hormodin powders used as specified above greatly increased the root system. All of the plant hormone powders caused an increase in the number of cuttings with roots. Maximum results were achieved with Hormodin No. III. Other treatments were intermediate (19).

Various experiments have been carried out regarding the best means of propagating garden sage by both seed and cuttings. The latter constitutes the better method. At the College of Agriculture, in Athens, Georgia, cuttings have been rooted in the greenhouses and transplanted to two-inch pots, then transferred from the pots to the field in April. This is more expensive procedure than transplanting directly to the field from the cutting bed, but is desirable where it is economically possible, as practically no losses of plants occur in carrying out this type program.

Since sage is a hot weather crop, it transplants with a minimum amount of loss from dry weather, and if it is handled similarly to sweet potato plants, the grower will find this practice very satisfactory.

Sage seems to be perfectly adapted to the climate and soil of the cotton-growing sections in Georgia and in Tennessee.

To obtain the best quality and yield, not only is it necessary to carefully select the parent stock, but planting and cultivating must be handled carefully also, giving attention to the physical needs of the plant.

Sage should be planted from 15 to 24 inches apart in the row, and two and one-half to three and one-half feet between rows. The distance will depend upon the fertility of the soil. The more fertile the soil, the larger the plant, hence the need for more growing space.

Several thousand plants are required to fill one acre. According to experiments at the College of Agriculture in Athens, Georgia, sage will thrive satisfactorily on any soil that will grow cotton, but it seems to produce a better quality product on clay-loam soil.

Fertilization

Before planting, a high-grade commercial farm fertilizer should be drilled into the rows, as is done with cotton. Six or eight weeks later an additional side dressing of high grade farm fertilizer should be applied.

Establishing a crop of sage is more or less expensive, but, since it is a perennial, it can be depended upon to produce over a period of five to ten years. It is not uncommon to find plants of sage in the corners of a garden that have been growing without transplanting for 15 or 20 years. The Spice Island Company of San Francisco, California, says that the plant has an average life of three years (24). Since the cost of establish-

ing a planting will be divided between the number of years that the planting will produce, it is not a prohibitive cost. Normal production of sage in the cotton-growing States should average, after the first year's planting, from one to two tons per acre annually (2).

After a crop is established, fertilizing with a high grade farm fertilizer about the time growth starts in the spring and repeating about the first of June seems to sustain the sage through the season to its maximum production. Cultivating lightly through the spring and summer to control grasses and other weeds seems to be the only additional necessary care. Hardy, in plot experiments (9), found that two applications (each 600 lbs. per acre rate) of muriate of potash (60%) gave highest yield per plant and greatest total yields of dried herbage.

Because there often are dry periods in summer, an experiment was conducted in Tennessee to determine the effect of an oat-straw mulch on the production of leaves and tender stems (19). Nitrate of soda was applied to both the mulched and non-mulched plots. The size and vigor of the plants was much increased by the mulching.

So far as has been determined, sage is not subject to any pathogens other than nematodes. Care should be taken therefore, to avoid the use of land in which these organisms are known to be.

Harvesting

Garden sage can be harvested during the fall of the first year. Two or three annual harvestings can be made thereafter.

The highest grade product is obtained by harvesting only the leaves. A much cheaper method, involving cutting the stems three to five inches long, or that part of the stems on which the leaves are growing, provides an excellent product. Still cheaper methods have been practiced, but they give a much lower quality product. One of these methods is cutting the crop with a mowing machine, the cutter bar set at the proper height, and the sage then gathered into piles with a hay rake.

The first harvesting is usually done when the plants begin to bloom. A second and third can be made between this period and frost time, depending upon the growing season.

Preparation

The herb gardener usually cures his sage by cutting it towards the end of the summer and then hanging the reapings in bunches in a dry, airy place.

Dehydration by modern methods is the most satisfactory manner of curing sage for market and gives the highest quality product obtainable. However, sage can be cured by spreading the crop thinly in the shade where drying takes place slowly. A lower quality product will be obtained from this method, since drying should be continuous from the time the foliage is harvested, and air-dried sage will give a darker colored product, which has less value on the market. In some sections, community dehydrators have been used, and tests show that this can be done with advantage to the various growers.

If a dehydrator is employed, the temperature should be started at 100 degrees Fahrenheit and carried on for four hours; then the temperature is raised to 118 degrees Fahrenheit for four hours. This usually gives the best quality product which will vary slightly with the moisture content of the foliage. The moisture should be reduced to approximately 13% (2). It is said that cultivated sage bears more sand than wild-growing material; it must therefore be thoroughly washed before drying.

Immediately following dehydration the product should be shipped to market without any delay as the loss of volatile oils is continuous. Shipping sage in

laundered fertilizer or feed bags is satisfactory and much cheaper than in boxes or crates.

Constituents

The economically important component of this plant is the volatile, or essential, oil which composes, according to various authoritative texts, 0.5, 1.3, 2.0, 2.5, 2.6% (5) of the dried weight of the leaf. The oil is much more popular in Europe than in the U. S. The chief components are cineol, *d*- and *l*-pinene, salvene, sesquiterpene, *l*- and *d*-borneol ("sage camphor"), *d*-camphor (the ordinary camphor), the ketones α- and β-thujone (also denominated "salvone" and "salviol"). The oil has a considerable history, having been distilled, it is said, at the city of Worms in Germany in 1582 (28). The oil is produced today in Yugoslavia, Spain, Corfu, Syria and Russia. Oils from different sources show considerable variation in properties and constituents.

The herb also contains pentosans, a bitter principle, somewhat like marrubiin, resin, a small amount of tannins, malic acid (questioned by some), proteins, nitrates and other inorganic ash constituents.

Volatile Oil Yields

During a seven-year period, many of the importations of sage leaves into New York were analyzed for the yield of volatile oils. Determinations were also made of some of the physical and chemical characteristics of these oils. Table I records the average results of 11 such tests on Dalmatian sage (*Salvia officinalis*) and ten tests on Greek sage (*Salvia triloba*) as obtained by the method outlined in "Methods of Analysis A.O.A.C.", 1935, 447–449 (3).

In a study on the yield and oil content of clonal strains, early plantings produced very little seed. An oil assay of a seedling population gave 1.14% oil on an air-dry basis for leaves and tender stems. Average assay of 1.40% oil for stemless Dalmatian sage showed variance with quality and time of harvest. Greek, French and Spanish sages assay somewhat lower (4). These reports implied that the United States grower would need improved strains and mechanized production if he is to compete with European producers.

The Tennessee Agriculture Experiment Station conducted an experiment on the propagation and culture of garden sage in 1945 (19). They selected some clonal strains, isolated and propagated them. Two plots of each strain, 28 feet long, plants two feet apart in the row and three feet between rows, were available for yield records. A controlled random arrangement was used. Assay samples were taken from all 28 plants of a given strain and from cuttings. The assays are comparable within a given season, and data on yield and oil content of 15 clonal strains are presented in Table II. These strains were selected for desirable leaf and plant characters, but were random selections for assaying.

In these studies the oil from Dalmatian sage always gave a positive rotation and that of Greek sage always gave a negative rotation. This characteristic is of value in distinguishing between the two varieties.

Table I

Average Yields and Physical Properties of Dalmatian and Greek Sage Oils

	V/W Yield	Sp. Gr. 25°/25° C.	Op. Rot. 25° C.	Ref. Ind. 20° C.	Ac. No.	Est. No.
Dalmatian	1.7%	0.926	+ 9.1°	1.465	1.9	17.84
Greek	2.39%	0.914	− 12.8°	1.469	1.03	15.74

Table II
Garden Sage—Effects of Room Storage on Volatile Oil

Date	Yield V/W	Sp. Gr. 25°/25° C.	Op. Rot. 25° C.	Ref. Ind. 20° C.	Ac. No.	Est. No.
1/25/38	1.6%	0.923	+12.11°	1.464	1.22	16.24
8/15/38	1.2%	0.929	+13.15°	1.461	1.23	14.6

The yield of volatile oil is generally greater for the Greek than for Dalmatian sage. Variations in acid and ester numbers are not considered significant.

To determine the extent of loss of volatile oil from sage leaves upon exposure in the laboratory, a portion of some coarsely ground, uniformly mixed leaves was analyzed. The remaining portion of the sample was stored in the laboratory in an open shallow pan and analyzed seven months later (Table II). The decrease in oil amounted to 25%. This indicates that on long exposure a material proportion of the oil may be lost. The Swiss Pharmacopeia (ed. V) directs that the drug be protected from light.

Table III shows the yield of leaves and young stem, and oil content of garden sage per acre as grown and assayed at Jackson, Tennessee, in the years 1945 and 1946. The 1945 assay samples were cut July 7, August 24 and September 26, with one-quarter of the sample taken at each of the first two cuttings and one-half at the third. Leaves and under stems were gathered, and the samples dried in the shade by drawing air over them with an electric fan. The air-dry leaves and stems were carefully mixed and a sample taken for assaying on an air-dry basis. The 1946 samples were managed in the same way except that only an April 15 cutting was used. The later set of samples averaged 1.33% sage oil; the former 1.14% (4). The 1946 plants were one year older, and climatic differences between the two seasons probably account for the variations. By carefully checking the Table, it will be noted that the Tennessee clonal strain No. 5 had the highest oil content, although strain No. 8 had a somewhat larger yield of oil per acre.

Table III
Yield of Leaves and Young Stem and Oil Content of Garden Sage at Jackson, Tennessee (4)

Tennessee clonal strain No.	Yield of leaves and stems per acre 1945	Oil assays (percent)	
		1945	1946
1	1,942	1.40	1.50
2	2,048	0.90	1.60
3	1,348	0.90	1.40
4	2,168	1.20	1.60
5	2,076	1.60	1.60
6	346	1.40	...
7	2,004	1.00	1.80
8	2,492	1.40	1.40
9	1,366	1.10	1.50
10	852	1.00	1.00
11	2,829	0.90	1.01
12	2,170	1.20	1.03
13	2,048	1.00	0.55
14	1,879	1.00	1.42
15	2,406	1.10	1.20

In further checking the various Tennessee clonal strains, assays were made of samples from different dates of harvest of clonal strains No. 5 and No. 15. The percent of oil was calculated on an air-dry basis. These data, presented in Table IV, indicate that environmental factors have an important influence on oil content and that samples for assaying should be taken at the same time and under uniform conditions. This will help to explain some of the variations noted in Table III. The first and last cuttings each season tend to have a lower oil content than the midsummer cuttings. Since strain No. 5 assayed

Table IV
Volatile Oil Content of Garden Sage within Two Clonal Strains at Various Dates of Cutting

Tennessee clonal strain No.	Harvesting date (percent vol. oil)				
	April 15	May 17	June 19	July 30	Sept. 26
5	1.60	2.00	3.00	3.25	2.69
15	1.20	1.68	1.75	1.25	0.60

throughout the season higher in oil content than strain No. 15, it is suggested that a genetic factor also influences oil content. In Table IV a two-pound sample of sage, green weight, was used in most cases, from which a 200-gm. air-dry sample was taken for assaying.

Table V presents some data on variations in volatile oil content among plants within a given clonal strain. The two strains are not comparable as they were cut at different times. There are some differences among individual plants, although all plants of one strain assayed high and all of the other low. The plants grew in replicated plots on land selected for uniformity. Cultural treatments, harvesting and drying were uniform.

These studies indicate that both environmental and genetic factors influence sage oil content. If environmental factors were made as uniform as possible, high-oil assaying clonal strains could be selected and used for propagation.

Adulterants

Adulteration is now less common than previously, and sophistication with leaves of such sage species as *Salvia sclarea*, *S. sylvestris* and *S. pratensis* is rare (27).

Adulterants occasionally found in *Salvia officinalis* include the leaves of *S. lavandulaefolia* (Vahl) Gams, commonly known as Spanish sage, a perennial herb indigenous to Spain and the southwestern margin of France, where it thrives at up to 5,000 or even 7,000 feet above sea level (10). Its leaves are oblong-lanceolate, one to one and one-half inches long and one-fourth to one-half inch broad, smaller than those of *Salvia officinalis* and tending to be whorled on the stems. The apex is either acute or rounded; the base subcordate or rounded; the margin nearly entire, very slightly crenulate; and the surface much smoother than that of *S. officinalis*.

Another adulterant is the foliage of *Salvia triloba* L., commonly known as Greek sage, a perennial herb indigenous to the Mediterranean countries. Limited amounts of true sage were cultivated in Greece and imported through Athens before the second World War; hence both garden and Greek sage have come from Greece commercially.

Table V
Variations in Sage Volatile Oil within Two Clonal Strains Expressed as Percent by Weight of Air Dry Leaves and Young Stems

Tennessee clonal strain No.	Assays of sage oil from individual plants								
	24	25	26	27	28	29	30	31	32
5	2.28	2.60	2.71	2.65	...	...	...	...	...
6	...	...	...	...	1.55	1.65	1.09	1.21	1.25

Garden sage and Greek sage are easily distinguishable from each other. Greek sage leaves are broader, shorter, thicker, more woolly, with very short petioles, and with a less pronounced crenulate margin; also, the odor of Greek sage is characteristically aromatic. It contains up to **2.37%** of volatile oil quite commonly **(31)** and is stronger than common sage, but the flavor is much inferior to that of Dalmatian. The distinguishing features of the two oils have previously been presented.

Leaves of *Phlomis* species, which are tomentose with stellate hairs, are also seen as adulterants of *Salvia officinalis* **(31)**. The species *P. lychnitis* L. was sometimes found in France **(20)**.

The most common adulterants in *Salvia officinalis* are sage stems. These may be detected microscopically in the comminuted drug by the presence of numerous reticulate vessels and crystal-bearing cells **(31)**.

Impurities found in sage were limited in the National Formulary VIII **(17)** to **10%** of the stems of the plant and to not more than **2%** of other foreign organic matter; the drug was to yield not more than **25%** of crude fiber, not more than **10%** of total ash, and not more than **1%** of acid-insoluble ash.

Uses

Sage has had many uses in the past, but today its utilization is more or less confined to the food industry. It is a standard spice for different types of dressing and cheese. Sage is extensively employed by the meat industry as a flavoring agent and condiment, especially in fatty meats, such as pork sausages, and it is an important ingredient in many ground spice formulas intended for the seasoning of poultry and meats, as in stuffing for fat fowl (as goose), chowders, soups, fats, baked fish and salad dressings. The Germans are especially fond of sage. The oil is also used as a condiment. Frequent references occur in the literature to this use. Thus, in Charles Dickens' "Christmas Carol", the famishing but happy family were mentioned as "basking in luxurious thoughts of sage and onion" [to go with their roast goose]. "Farewell to sage and sassafras and corn dodger pills" occurs in "The State of Arkansas", a cowboy chant of the last century **(7)**.

Medicinally, sage has had a variety of uses as a mild tonic, as an aromatic bitter, an astringent and as a carminative; it is supposed to be slightly antiseptic also. The leaf infusion has been used as a gargle in the treatment of sore throats, oral ulcers, and elsewise for respiratory inflammations or "catarrhs". It was formerly used in medicine mostly for its stimulant, stomachic and intestinal astringent effects, particularly in treating diarrhea. The leaf in various dispensing formulations is also used as a vulnerary and expectorant, and tends to reduce perspiration, especially being used formerly for night sweats of tuberculosis **(5)**. Several American authors, for instance, Rusby *et al.* **(22)**, claimed that the hot infusion acted as a diaphoretic. The volatile oil has often been employed as a carminative in dyspepsia. It has also served as an adulterant for rosemary and lavender oils.

The dose of garden sage is four grams, or **60** grains.

Pharmacodynamic investigations have been made of some plant drugs alleged to have antipyretic action. Extracts of sage leaves were used in an experiment on guinea pigs and found to reduce the temperature of normal guinea pigs and guinea pigs with hyperthermia provoked by injection of β-tetrahydronaphthylamine. This may indicate a value as an antipyretic and an anti-diaphoretic.

An ether-soluble fraction of the benzene extract of dry sage produced the same effects as folliculin (= estrone) when injected into castrated female

mice. One kilogram of dried leafy tops contained about 6,000 international units of estrogenic substances, hence some female hormone activity. Sage has been prescribed for female disorders since ancient times, and this experiment demonstrates the possible validity of such usage.

Sage has found many household uses, sometimes as a substitute for other products. The dried leaves have served as a fumitory, and some claim that the leaves rubbed on teeth function as a good dentifrice. The southern Negroes are said to use it for toothache. At one time sage was popularly used in the form of a "Sage Bath"; the leaves were boiled and then the decoction put into the bath. This was thought to have a stimulating effect and to be a cure for sore muscles, inflammations and skin affections (5). The drug had some vogue in Europe as a vulnerary, mild aphrodisiac, and abortive (16).

Sage tea was used in England long ago as a favorite remedy for colds. In addition to the specific applications, sage has been credited with general health-giving properties and the reputed power to prolong life; and even with being able to "strengthen the memory".

The leaves or herb are official in several pharmacopeias in the world, was for many years in our own U. S. Pharmacopoeia, and was last monographed in the eighth edition of the National Formulary (17). The product was dropped from official recognition not because of disuse or uselessness in therapy but because a larger proportion is now used in the food industry than in the medicinal-pharmaceutical. The flowering tops and the volatile oil have also at times been official products.

The volatile oil has been and in some places is yet used in perfumes, as a deodorant, in insecticidal preparations, for treating gingivitis, thrush, etc. (15).

True sage must still be quite popular, as grocery stores often display it in their vegetable departments, usually in small glassine envelopes at rather high prices. Recently, ⅜-ounce packages originating from a West Virginia grower retailed at 19¢ or at the rate of $8.11 per lb. The price on the drug market in bulk quantities (bags) has recently run from 11¢ for Cretan to 13¢ for Italian to 40¢ for Dalmatian, the latter representing the best quality (18). Its value as a beverage tea was recognized by the Chinese so that at one time the Dutch carried on a profitable trade in exchanging sage for tea, pound for pound.

The most popular mode of use undoubtedly has been the infusion or "sage tea" which was official in the U. S. Pharmacopoeia 1860–70. It is often given mixed with honey. The herb has been used in tooth and mouth washes, gargles, cataplasms (poultices) and tooth-powders (29); and in hair tonics and hair dressings, such as "Sage and Sulphur", a favorite proprietary product.

The volatile oil has long been known and used. The tincture is commonly handled by German pharmacists (14). The fluid extract is also known.

Sage is an official component of Species Aromatica (Aromatic Tea) of the French, Swiss, and Belgian Pharmacopeias, and in the Tinctura Aromatica (Aromatic Tincture) of the same compendia. Aromatic Tea never has been an official preparation in the United States, and the Aromatic Tincture of N.F. IV and V contained no sage.

"Rubbed Sage" is a crushed or bruised form used in domestic practice; it is a more available medicinal agent than the whole leaves commonly seen; the latter, however, keep better. Ground sage is also sometimes seen.

Sage cheese, or "green cheese", was a cheddar (now American) cheese flavored and mottled with a decoction of the leaves or with the leaves themselves.

Some idea of how it was made in the old days is conveyed in the line of Gay (1685–1732): "Marbled with sage the hard'ning cheese she press'd". Another culinary preparation was an excellent pickle made by the French from the tender leaves.

The popularity of garden sage among herbs is evident from its usage dating to very early times as well as from its current popularity in the discriminating household. It seems likely that it will always be found on spice shelves and will remain as characteristic a landmark in many gardens of the future as it was in the days of yore.

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Toxicological Studies of Southeastern Plants. II. *Compositae*[1]

Three native species of Baccharis are here reported to be poisonous and thus to constitute a menace to grazing cattle and sheep.

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This article is the second [5] of a series describing the results of studies of the effects of plant material administered to experimental animals under controlled conditions. The studies are designed to provide primarily a basic survey of acute toxic effects. These effects indicate, in some instances, possibilities for investigation of previously unexplored potential sources of medicinally active plant materials and enlarge upon toxicological knowledge of clinical value to veterinarians and others. Two of the four species of Compositae covered by the basic survey of the present studies gave positive results. These results prompted limited studies of extracts. The studies gave positive results for a third species. Results of the basic survey and of the studies of the extracts are reported here.

The Composite Family

Several genera of this family contain species which have been reported to be toxic to animals. Muenscher (6) lists 22 genera that include at least one poisonous species each. Included are species in the genera *Baccharis* and *Aplopappus*, but none is from the southeastern United States. *Baccharis* species from areas outside the southeastern United States have been reported to have biological activity. *B. cordifolia* DC., commonly called "Mio Mio", is, according to Oslo and Farrar (7), notorious for its deadly effect on sheep and cattle in southeastern South America. The entire plant is highly toxic and has yielded the alkaloid baccharine. Baccharine extracted from *B. pillularis* DC., commonly called "kidney-root" and occuring along the Pacific coast of North America, has had limited medicinal use in treatment of certain urinary diseases. Oslo and Farrar (7) also state that *B. genistelloides* Pers., a Peruvian species, has yielded a glycoside, baccharonin.

Apparently only one species of *Baccharis* has been reported previously as poisonous in the United States, Marsh (4) stating that *B. pteronioides* DC. (= *B. ramulosa* Gray), a low shrub of New Mexico, Arizona and Mexico, is poisonous to sheep and probably to cattle. It is toxic for sheep when consumed in amounts equivalent to one percent or more of the body weight. Huffman and Couch (3) report toxic manifestations as extreme prostration and severe gastritis.

Among the species of *Aplopappus*

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[2] Department of Botany.
[3] School of Veterinary Medicine.
[4] School of Pharmacy.

[5] Part I in Econ. Bot. 9: 243–255. 1955.

TABLE I

LIST OF COMPOSITAE STUDIED FOR TOXIC PROPERTIES TOGETHER WITH DATA ON GENERAL ECOLOGY AND DISTRIBUTION, NUMBER OF COLLECTION AND PLANT PART FED, AMOUNT OF PLANT MATERIAL FED, EXPRESSED AS PERCENTAGE OF BODY WEIGHT OF EXPERIMENTAL ANIMALS, ANIMAL SPECIES USED WITH WEIGHTS IN GRAMS, AND TOXICITY IN BASIC SURVEY

Scientific and common name General ecology and distribution	Collection number	Plant part fed	Equivalent % of animal body weight	Animal and weight in grams	Toxicity
Baccharis angustifolia Michx.	13776 *	Leaf, stem tip	0.83–1.25	Mouse 16–24	Negative
(False willow, Narrowleaf baccharis)	13776	Leaf, stem tip	1.66–1.78	Chick 80–86	Negative
Salt marshes and swamps, low	14424	Leaf, flower	1.52–1.62	Chick 77–83	Negative
hammocks.	17434	Leaf, flower bud	3.30–3.75	Chick 92–102	Negative
Coastal Plain. Fla. to Tex. and N. C.	17453	Leaf, flower	1.39–2.30	Chick 86–95	Negative
Baccharis glomeruliflora Pers.	14081	Leaf, flower	0.98–1.25	Mouse 32–41	Positive
(Groundsel-tree, Silverling,	14081	Leaf, flower	1.00–1.25	Mouse 32–40	Positive
Southern baccharis)	14081	Leaf, flower	1.52–1.76	Chick 112–130	Positive
Salt marshes, swamps, and hammocks.	14081	Leaf, flower	1.63–1.69	Chick 85–88	Positive
Coastal Plain. Fla. to N. C.	14081	Leaf, flower	1.02–1.82	Chick 87–155	Positive
(female plants)	17388	Leaf, flower bud	3.37–3.72	Chick 76–84	Positive
	17388	Leaf, flower bud	1.07–1.85	Chick 85–98	Positive
	17433	Leaf, flower bud	3.09–3.29	Chick 90–96	Positive
	17433	Leaf, flower bud	1.64–2.49	Chick 85–114	Positive
	17452	Leaf, flower	0.96–1.47	Chick 114–120	Positive
	17452	Leaf, flower	3.20–3.62	Chick 90–96	Positive
Baccharis glomeruliflora Pers.	17451	Leaf, flower	1.68–1.89	Chick 96–108	Positive
(male plant)	17451	Leaf, flower	3.15–3.43	Chick 90–98	Positive
Baccharis halimifolia L.	14419	Leaf, flower	0.60–0.88	Mouse 17–25	Negative
(Groundsel-tree, Silverling,	14419	Leaf, flower	0.87–1.11	Mouse 18–23	Negative
Eastern baccharis)	14419	Leaf, flower	1.21–1.29	Chick 77–82	Negative
Salt marshes, beaches,	14419	Leaf, flower	1.31–1.57	Chick 75–89	Negative
rather open situations,	17381	Leaf, flower	1.92–2.19	Chick 98–112	Negative
low ground inland.	17385	Leaf, flower bud	3.24–3.47	Chick 84–90	Positive
Coastal Plain and Piedmont.					
Fla. to Texas, Mexico, and					
Coastal Mass.					
(female plants)					

TABLE I—*Continued*

Scientific and common name General ecology and distribution	Collection number	Plant part fed	Equivalent % of animal body weight	Animal and weight in grams	Toxicity
Baccharis halimifolia L. (male plant)	14420	Leaf, flower	1.26–1.36	Chick 76–82	Negative
	17372	Leaf, flower bud	2.22–2.47	Chick 88–100	Mildly positive
Haplopappus divaricatus (Nutt.) Gray	14320	Inflorescence tip	0.63	Mouse all 40	Negative
Isopappus divaricatus (Nutt.) T. & G.	14320	Inflorescence tip	0.63–0.71	Mouse 42–48	Negative
Dry fields, open places.	14320	Inflorescence tip	1.50–1.71	Chick 107–123	Negative
Fla. to Va., Tex., and Kan.	14320	Inflorescence tip	1.55–1.72	Chick 105–117	Negative

* The sex of No. 13776 is unknown, No. 14424 is male, and Nos. 17434 and 17453 are female.

(*Haplopappus*), *A. baylahuen* Remy, an herb native to Chile, is reported by Oslo and Farrar (8) to contain a volatile oil, a brown acid resin of sharp taste, and tannin. This species has been used medicinally as a stimulant in flatulent dyspepsia and chronic colitis. In southwestern United States *A. heterophyllus* (Gray) Blake (Rayless goldenrod) is reported by Marsh (4) to be associated with losses accompanying the disease popularly known as " milk sickness ", " alkali disease " or " trembles ". Cattle affected by eating the plant exhibit muscular trembling and weakness, especially after exercise. The poisonous principle is released from the affected animal in the milk in sufficient amount to cause " milk sickness " in humans who consume the milk. Horses and sheep, too, are affected by grazing this species. Another rayless goldenrod, *A. fruticosus* (Rose & Standl.) Blake, also in southwestern United States, produces harmful effects similar to those caused by *A. heterophyllus*.

Three species of *Baccharis* and one of *Haplopappus* (often included in *Aplopappus*) which are common in parts of the Southeast were suspected because other poisonous species of *Baccharis* are found elsewhere and because of complaints in this area from cattlemen of poisoning by certain species of the present study. These four species were routinely studied in the laboratory, the experimental methods, procedures and animals used for this basic survey being described in detail by Duncan, Piercy and Starling (2). The three *Baccharis* and one *Haplopappus* species are enumerated in Table I together with important synonyms, common names, general statements of ecology and distribution, collection numbers, plant parts collected and fed, experimental animals used, animal weights, amounts of plant material fed (expressed as percent of body weight of the experimental animal) and indication

of toxicity. Locations from which collections were made and other data for all experimental plant collections are tabulated on herbarium specimens on file in the University of Georgia Herbarium.

Results of Basic Survey Studies

Baccharis glomeruliflora and *B. halimifolia* are demonstrated by the basic survey to produce toxic manifestations. Contrariwise, *B. angustifolia* and *Haplopappus divaricatus* produced no toxic manifestations in birds and mice. Studies (described in later pages) of extracts of *B. angustifolia* demonstrate that this species also is toxic. The toxic manifestations of the three *Baccharis* species indicate the presence of one or more active principles which may be of medicinal importance and which suggest a high probability of importance as species being poisonous to grazing livestock. The descriptions which follow should aid the reader in identifying these three toxic *Baccharis* species.

Description of Toxic Species

Baccharis angustifolia Michx. A shrub to 2.5 meters tall, resinous; leaf blades narrowly linear, 1–8 cm. long, entire or nearly so; flowering in the fall or all year in southern Florida, the male and female flowers borne on separate plants (i.e., dioecious); the flowers in heads; bracts of the female flower heads 4–5 mm. long; the number of flowers per head many; achenes 1–1.5 mm. long, nearly terete, glabrous, and provided on the summit with a series of bristles which aid in dissemination of the fruits by wind. Almost entirely confined to coastal areas from North Carolina to peninsular Florida and Texas where it occurs in moist, usually brackish, situations.

Baccharis glomeruliflora Pers. A dioecious shrub to 3 meters tall, not resinous (only occasionally barely resinous); leaf blades spatulate to cuneate-obovate, 2–5 cm. long, often sharply toothed; flowering in the fall or all year in southern Florida, the flowers in heads; bracts of the female flower heads 5–6 mm. long; the number of flowers per head many; achenes 1.5 mm. long, otherwise similar to those of *B. angustifolia*. Occurs in salt marshes, swamps and low ground of the Coastal Plain from western Florida to North Carolina. Occurs also in hammocks in the interior of the Florida peninsula.

Baccharis halimifolia L. A dioecious shrub to 4 meters tall, resinous; leaf blades elliptic to broadly obovate, up to about 6 cm. long and 4 cm. wide, at least some of them coarsely toothed, especially above the middle; flowering about the same time as *B. glomeruliflora;* the flowers in heads; bracts of the female flowers about 6 mm. long; the number of flowers per head many; achenes about 1.5 mm. long, otherwise similar to those of *B. angustifolia*. Found in the same situations as the two previous species and also in low grounds inland to the Central Piedmont of Georgia and South Carolina. Occurs from Massachusetts to Florida, Arkansas, Texas and West Indies.

Results of Experimental Feedings

It should be noted that normality prevailed after feedings of test material of *Baccharis angustifolia* and *Haplopappus divaricatus* and that there was thus no evidence of toxicity from these species manifested in either chicks or mice (Table I). Evidences of toxicity were observed for male and female plants of both *B. glomeruliflora* and *B. halimifolia*. Collections of both species from various and mostly widely separated localities allow analyses in respect to variability in toxicity from one locality to another. Details of the feeding tests of these two plant species are as follows:

Baccharis glomeruliflora. Leaves and flowers. No. 14081, female plant. Mice

were employed in two trials with this specimen. The first group of five received amounts equaling 0.98 to 1.25 percent of the body weight and the second group 1.00 to 1.25 percent. It was lethal to all mice within 15–20 minutes after feeding, death being marked with diarrhea but without struggle. Autopsy examinations revealed nothing significant.

Three groups of five chicks each received this plant material in body weight percentage equivalents ranging from 1.02 to 1.82 and it was fatal to all. In the first group of five the first evidence of toxicity, mild depression, was observed one hour after feeding. At 1¼ hours, heart and respiration rates were increased 10–12 percent and continued so until shortly before death when they subsided to levels below the normal. Three hours after feeding the plant, anorexia, weakness, listlessness and subnormal rectal temperatures were noted. Death occurred in these birds in post-administration intervals ranging from 2¼ to 10 hours. Similar symptoms were observed in the second and third groups of chicks receiving 1.63 to 1.69 and 1.02 to 1.82 percent of body weight, respectively, of plant material No. 14081.

Baccharis glomeruliflora. Leaves and flower buds. No. 17388, female plant. Two feeding trials were conducted with this specimen. The first group of five experimental chicks received amounts equivalent to 3.37 to 3.72 percent of the animal body weight. All birds exhibited marked listlessness and ruffling of the feathers within 2½ hours after administration, the manifestations being most severe in one bird which showed ataxia, in addition, and which was dead within 3¾ hours after feeding. The autopsy examination of it revealed hepatitis and the crop was impacted and enlarged by the presence of the plant material. Another bird was dead in four hours and the remaining three died at intervals up to 20 hours after administration.

The second feeding trial with specimen No. 17388 was designed to use smaller dosage concentrations in hope of determining the effect that crop impaction with the dry plant material may have had on birds in the first trial. Four birds were each fed three capsules, each capsule containing 524 mg. of dried plant material. A fifth bird (number 793) received one 524 mg. capsule initially and a second one two hours later. The bird was near death at four hours and the third capsule could not be administered. At 1½ hours following administration all birds receiving three capsules were listless and depressed with muscular weakness indicated by drooped wings. The eyes were closed and crop impaction was detected by palpation. These manifestations were retained until death which occurred to all birds within 22½ hours. Bird 793 was weak, depressed, semicomatose, showed shallow and weak respirations, and on palpation appeared to have passed very little, if any, of the plant material from the crop by four hours and two hours, respectively, after receiving the first and second capsules. It died at 4¼ hours after being administered the first capsule and was submitted to autopsy examination. Lesions were limited to a severe edema completely surrounding the crop. There was no evidence that any of the plant material except soluble elements had passed from the crop.

Baccharis glomeruliflora. Leaves and flower buds. No. 17433, female plant. Two feeding trials with this sample were run on chicks. The first trial employed five birds, each of which received a single dose representing 3.09 to 3.29 percent equivalent of the animal body weight. All birds were examined six hours after administration of the capsules and showed no evidence of toxicity. The following morning, 21 hours after

administration, all were dead and each had a severely impacted crop with no evidence that any of the insoluble crop content had passed to the proventriculus. Decomposition was too advanced to otherwise permit a satisfactory autopsy.

In the second feeding trial with specimen number 17433, emphasis was placed on autopsy studies. Five birds were employed, the amount of plant material given being equivalent to from 1.64 to 2.49 percent of the body weight. Four chicks exhibited no symptoms at the end of the first three hours, while the fifth chick was dead at that time. Death had occurred in the remaining four birds by 6½ hours following initial feeding. All were subjected to autopsy examination. Lesions included mild to extremely severe edema through the ventral portions of the body, especially in the crop region. Three of the birds showed slight to moderate petechiation in the duodenal mucosa. The coronary vessels of the bird which died within three hours after receiving the plant material revealed numerous ruptures. A slight degree of coronary congestion was detected in a second bird, but no such evidence prevailed in the remaining three birds. Examination of the alimentary tract revealed that some of the crop contents had passed out of the crop to the proventriculus and ventriculus. There was slight pulmonary edema in two of the five birds. These findings were most striking with respect to the altered circulatory physiology. While it is possible that the mechanical interference caused by crop impaction may have been partially responsible for some of the edematous alterations, it is believed that the plant probably contains a poisonous element or elements which may have the ability to increase the porosity of circulatory vessels, thus explaining the accumulation of edematous fluid and perhaps even the vasodilation as well as the vascular rupture and consequent hemorrhage. In addition, some neuro-muscular depressant action is suggested. Lesions were most marked in the birds receiving the higher dosage concentrations.

Baccharis glomeruliflora. Leaves and flowers. No. 17452, female plant. An initial feeding trial with this material employed five chicks, each of which was given a dosage equivalent to 3.20 to 3.62 percent of the body weight. In four hours after administration one bird exhibited muscular weakness, listlessness, ataxia and dyspnea. All birds were dead by seven hours after the plant material was given. Other observations on this group were limited to noting the presence of crop impaction, with little indication that any of the insoluble crop contents had passed from the crop.

These results prompted studies additional to those made with specimen 17388 on the possible influence that mechanical involvement in the retention and impaction of the crop contents may have had on the fatal results. Four chicks were given a dosage varying for each from 1.40 to 1.47 percent equivalent of the body weight. The fifth bird received one capsule containing 558 mg. initially and a second capsule two hours later, a total of 0.96 percent of body weight; it exhibited extreme listlessness, weakness and dyspnea two hours after receiving the second capsule and was dead 15 minutes later. Autopsy revealed a severe edema surrounding the crop and slight inflammation of the crop mucosa. Very little of the crop contents had passed on to the proventriculus. One of the four birds receiving the larger single dosage was destroyed for autopsy seven hours after receiving the plant material, at which time most, if not all, of the plant material was retained in the crop, dyspnea was marked, and the bird was extremely depressed and uninterested in altering its position in any way. Autopsy revealed a very severe gelati-

nous edema extending over the ventral area of the cervical and sternal regions, petechial hemorrhages throughout the duodenal mucosa, and hyperemia of the cardiac muscle. The remaining three birds on ante-mortem examinations revealed the same manifestations as above and were especially noted to show retention of the plant material within the crops. They were all dead at the end of 23½ hours after the plant material was given but were not subjected to autopsy examination. The symptoms in all five birds and the autopsy findings in the two examined suggested the presence of one or more toxic factors in the leaves and flowers of *B. glomeruliflora*. The toxic activity is concerned with altering the physiology of the circulatory system and possibly with a neuro-muscular alteration that, in this instance, depressed activity of the crop musculature.

Baccharis glomeruliflora. Leaves and flowers. No. 17451, male plant. In the first trial with this specimen, five chicks received plant material equivalent to 3.15 to 3.43 percent of body weight; in a second trial with five chicks, 1.68 to 1.89 percent. Symptoms from this material of the male plant were similar to those obtained with tests of the female plant. Death occurred in all five chicks within 4½ hours from the heavier dose, and from 5½ to 22½ hours in the case of the lighter dose. External and internal symptoms again suggested some degree of interference with circulatory and neuromuscular physiology.

Baccharis halimifolia. Leaf and flower (or flower bud). Male and female plants. It may be noted in Table I that feedings to two groups of mice and four groups of chicks of specimens number 14419, 17381 and 14420 in amounts equivalent to 0.60 to 2.19 percent of body weight gave negative results, while the larger feedings of specimens number 17372 and 17385 in amounts equivalent to 2.22 to 3.47 percent gave positive results. It is interesting to note that the largest concentration, 3.34 percent of the body weight (of 17385), produced distinct evidence of toxicity and was fatal to all birds, while dosages equivalent to 2.41 percent of the body weight of 17372 caused only mild to moderate depression in all birds, followed by recovery. Thus it is indicated that the marginal safety is less than 2.22 percent. Of the birds fed the highest dosage of specimen 17385, all appeared normal at 6½ hours after administration but showed marked evidence of toxicity at 34 hours. The manifestations included extreme depression and listlessness with ruffled feathers and hunched posture. Three of the birds were dead in 52 hours after feeding, another in 72 hours. The fifth bird was destroyed for autopsy 35 hours after feeding, the autopsy findings including a slightly anemic liver, gall bladder distension, and vasodilation of visceral vessels. Similar but more distinct lesions were found in the chick that died within 72 hours and included an anemic and friable liver, a greatly distended gall bladder, petechiation throughout the duodenal mucosa, and extreme dehydration. No autopsy was made on birds dead in 52 hours. It thus appears probable that the toxic factor or factors in *Baccharis halimifolia* possess properties which alter hepatic and circulatory physiology.

Summary of Results of Basic Survey

The toxic manifestations produced by *Baccharis glomeruliflora* were well marked in all instances. Regardless of the dosage administered, crop impaction was exceedingly great and approached nearly complete paralytic proportions. Edematous infiltration in the proximity of the crop was a consistent finding, indicating an altered circulatory physiology. Hemmorrhagic lesions of varying extent were present in the intestinal tracts of several experimental chicks.

Although not consistent in occurrence, it provided additional evidence of circulatory involvement. Heart and respiration rates of mice appeared to be increased until shortly before death when they subsided to levels below the normal. The extreme listlessness exhibited by all birds was accompanied by anorexia, ruffling of the feathers, hunched posture and closure of the eyes. The severity of the toxicity produced by *B. glomeruliflora* in all dosage levels administered is emphasized by the fact that all experimental birds died in less than 24 hours after administration of the plant material and none recovered. The fatality was even more dramatic in the experimental mice in which the plant proved lethal within 20 minutes after feeding.

Although death occurred in all experimental chicks and the symptoms were generally uniform in character, it should be pointed out that time of onset of symptoms and occurrence of death was often irregular in terms of the size of the administered dosage. This is undoubtedly due to variation in rate of absorption of the toxic principles from one animal to another and one feeding trial to another. Varied absorption may have been partly due to the fact that palpation of the crop and irrigation with water were not always uniform from one trial to another, and that, although in any given trial treatment was generally uniform from chick to chick, the effects on the condition of the crop contents were not uniform. There was considerable indication that a portion of the toxic substance(s) entered the systems of the chick via the crop tissues.

Symptoms and lesions caused by *Baccharis halimifolia* in experimental chicks were observed when dosage levels of the plant were administered in amounts equivalent to 2.22 percent or more of the body weight. No abnormalities were noted in any of the experimental birds receiving lower dosage levels. The manifestations of toxicity ranged from mild depression and recovery on the lower toxic levels to extreme listlessness and stupor, ruffling of the feathers, hunched posture, gall bladder distension, duodenal petechiation, hepatic friability and anemia, and death on the higher dosage levels.

It is evident from the basic survey studies that *Baccharis glomeruliflora* and *B. halimifolia* are toxic to chicks and that the subtoxic doses are, respectively, somewhere below 0.96 and about 2.19 percent. There seems to be little, if any, difference in toxicity of male and female plants of either species or of plants of the former species from widely separated localities. It is evident that *B. glomeruliflora* is toxic to mice, but the data do not demonstrate that *B. halimifolia* is toxic to them. It should be noted in case of the latter species that the percent equivalent of body weight fed to mice is less than that fed to chicks exhibiting no toxic symptoms. Larger or repeated feedings to mice would probably give positive results.

Results of Toxicity Studies of Extracts

Baccharis halimifolia, *B. angustifolia* and *B. glomeruliflora* were extracted by a modification of the method proposed by Curts and Harris (1), using ethylene glycol monoethyl ether (cellosolve) in a soxhlet extraction apparatus. The solvent selected has the properties of

TABLE II

CELLOSOLVE AND AQUEOUS EXTRACTS FROM THREE *Baccharis* SPECIES

Species	Original Sample	Fraction I Cellosolve		Fraction II Aqueous	
	gm.	*gm.*	*%*	*gm.*	*%*
B. halimifolia	539	171	30.1	87	6.8
B. angustifolia	500	185	37.0	72	14.4
B. glomeruliflora	401	211	52.6	22	5.4

TABLE III

Comparative Toxicity of Cellosolve (I) and Aqueous (II) Extracts from Three *Baccharis* Species

Species	Fraction	LD_{50} mg./Kg.
B. halimifolia	I	2620 ± 108
	II	2060 ± 102
B. angustifolia	I	2000 ± 104
	II	1150 ± 118
B. glomeruliflora	I	68.0 ± 10.3
	II	215.0 ± 10.7

alcohol, chloroform, ether and benzine, and is miscible with water.

After extraction with cellosolve the exhausted marc was dried and extracted with boiling water to give two fractions from each plant: (I) cellosolve-soluble and (II) water-soluble extracts. The respective fractions were evaporated to dryness under reduced pressure. Results of the extraction are presented in Table II and illustrate the solvent properties of cellosolve and the residual material extracted with water.

Each plant fraction was then evaluated for comparative toxicity by determining the LD_{50} for Swiss strain albino mice.

The dry extracts were suspended in an emulsion of bland oil, water and polyethylene sorbitan monooleate, and were administered by intraperitoneal injection to a total of 430 adult albino mice. The method of Miller and Tainter (5) was used to calculate the LD_{50} with death occurring in 48 hours after injection as the maximal limit. Results for the three species are shown in Table III. The general uniformity of toxicity in the two fractions may be explained by the presence of different toxic components or by a single compound only slightly soluble in cellosolve but readily water-soluble, subsequent investigation supporting the latter hypothesis.

Symptoms of toxicity prior to death were peripheral vasoconstriction, locomotor ataxia, loss of sensory perception, and progressive ascending paralysis involving respiratory centers. Post-mortem examinations revealed massive internal hemorrhage and pulmonary edema. Ante-mortem examination of comatose animals receiving *B. glomeruliflora* repeatedly revealed a characteristic systolic tonus with auricular flutter. Subsequent investigation was limited to *B. glomeruliflora*.

The cellosolve extract was redispersed in the original solvent and studied according to the suggested scheme. Traces of a fixed oil were present, and large quantities of resinous material were extracted with chloroform after precipitation by addition of water. The usual reagents gave no indication of the presence of alkaloids. The remaining aqueous cellosolve mixture frothed copiously and hemolyzed blood in dilute concentration, indicating the presence of a saponin. The aqueous saponaceous material was treated with lead acetate to precipitate organic acids and pigments, and the excess lead was removed by passing hydrogen sulfide through the solution.

Filtration of this solution gave a clear yellow fraction and upon evaporation yielded a yellow crystalline material with saponaceous and toxic properties. Hydrolysis of the crystalline material with dilute hydrochloric acid yielded a non-reducing sugar and an aglycone fraction with only slight hemolytic and toxic properties.

During 21 days, five adult Swiss mice were administered a diet consisting of twenty-five percent by weight of powdered *Baccharis glomeruliflora* intimately mixed with powdered commercial dog ration and massed with a bland oil to prevent selective feeding. The mixture was readily accepted after the first day and water was given ad libitum. Animals averaged a loss of 20% of normal

TABLE IV

LOSS OF BODY WEIGHT IN MICE DUE TO *Baccharis glomeruliflora*

Animal number	Normal weight	Seven days		Twenty-one days	
		Weight lost	% Body wt.	Weight lost	% Body wt.
1	29.9	4.9	(16.3%)	8.9	(29.4%)
2	27.5	7.5	(27.2%)	Dead	
3	28.0	5.0	(17.9%)	9.0	(31.0%)
4	23.5	3.3	(14.0%)	Dead	
5	30.0	7.7	(25.6%)	Dead	

body weight in seven days. In 21 days three animals died and the remaining two lost about 30% of normal weight. Individual animal losses are given in Table IV. The emaciated condition of the survivors and an alopecia of unexplained mechanism are illustrated in Figure 1. Upon discontinuing the *Baccharis* in the diet, the animals rapidly returned to normal. A Garceau electroencephalograph was adapted to record the normal cardiac impulses of the mice prior to the feeding experiment. Electrodes I and III were implanted in the right and left thoracic wall, respectively, and normal tracings obtained. Recordings were again taken seven days after the *Baccharis* diet was begun. The tracings were not significant, due to inconsistent responses of the animals. Rodents are known to be especially resistant to digitalis types of glycosides (Sollmann, 9), and the feeding experiment established chronic toxicity with oral administration.

Fig. 1. Photograph of emaciated and alopecic mouse after 21 days of *Baccharis* administration.

Electrocardiographic studies were made on dogs with sublethal quantities of fresh aqueous extracts injected intravenously. Typical records are presented in Figure 2. Note the prolonged P-R interval and the inverted T wave characteristic of digitalis glycosides.

Blood pressure studies were made on adult female mongrel dogs by the usual method. Carotids were cannulated and attached to mercury manometers to record pressure changes on a smoked Kymograph drum.

Intravenous injection of extracts of *Baccharis* consistently gave a slight elevation of blood pressure in accordance with the reported direct constrictor action of digitaloids on arterioles (Sollmann, 9).

The toxicity of *B. glomeruliflora* is thus shown to be due primarily to the presence of a glycosidal saponin related in activity to digitalis and should proba-

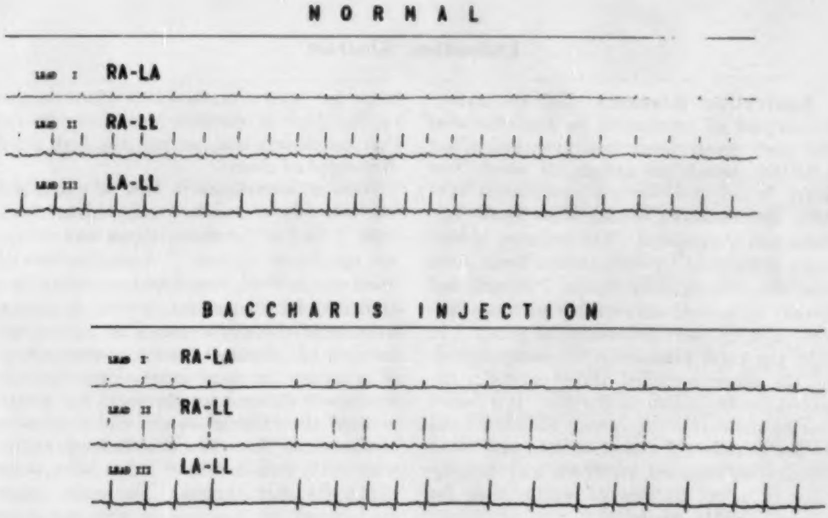

FIG. 2. Electrocardiograms (10 seconds) before and after intravenous injections of *Baccharis* extract.

bly be classified with digitaloidal glycosides of squill, *Apocynum*, hellebore, *Adonis*, and *Convallaria*.

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10. *Ibid.* p. 455.

Utilization Abstract

Australian Essential Oil Industry. Eucalyptus oil production in Australia over the past seven years has averaged about 1,500,000 pounds per annum, of which New South Wales and Victoria contributed over 90%, the remainder coming from South Australia and Queensland. The industry is seriously threatened by competition from other countries, among them Spain, Portugal and Brazil; by several unfavorable economic factors; and by local governmental policy. In 1955 the total production of eucalyptus oil by the aforementioned three countries exceeded the Australian production. It is feared that by not correcting various conditions and by not prohibiting export of seed and other propagating material, Australia may lose the industry as it did that of wattle bark for tannin to South Africa.

" One of the most sought after Eucalyptus oils is that derived from the Queensland lemon-scented gum, *Eucalyptus citriodora*. It has had a chequered career for many years because of its prohibitive price compared with closely allied oils derived from the citronella grasses of Java, Ceylon and Formosa. Notwithstanding this competition, the oil of *Eucalyptus citriodora* is the richest source of citronellal in the world. This substance is readily converted into citronellol which is one of the principal constituents of synthetic rose oil and is also used for the manufacture of hydroxycitronellal and menthol. The only economical method of producing this oil, for which there is still a good demand, is by the establishment of plantations. *E. citriodora* is a tree which responds readily to cultivation, and although it is by nature a timber-producing tree, it can be specially pruned to produce abundance of foliage if required for oil . . . it is also one of the principal hardwood timbers of Queensland. The Queensland Forest Service tries to encourage production of oil from this tree by permitting distillation of foliage from timber trees felled in the forest areas. However, there has been a marked lack of enthusiasm on the part of distillers owing to the fact that purchasers will not pay the high prices demanded of them ".

Next in importance to that of eucalyptus are the oils of sandalwood, of the " tea-trees ", and of lavender, citrus and several less significant sources. " Australian sandalwood oil [derived from *Eucarya spicata*] was marketed for its santalol content in competition with the well-known East Indian sandalwood oil [obtained from *Santalum album*] of commerce for many years. Unfortunately, continuous demand for the wood has greatly reduced the existing stands, and production of the oil in Australia has declined greatly since 1945, with the result it has fallen below 10,000 lbs. per annum. The main use of sandalwood oil today is in the perfumery trade, although small quantities are exported to Malaya for self-medication ".

Tea-tree oils are furnished by several Australian species, among which are *Leptospermum citratum*, *Melaleuca alternifolia*, *M. bracteata* and *M. viridiflora*. The oil from the first of these is highly prized as a source of citral, but the bulk of the oil in commerce, including much of that utilized in Australia, is obtained from extensive plantations in Kenya. *Melaleuca alternifolia*, growing along water courses and in swampy situations of northern New South Wales, furnishes over 50,000 pounds annually of an oil known under the proprietary names " Ti-trol " and " Melasol ", for it finds extensive application in surgical and dental practice. *M. bracteata* furnishes an oil with marked adjuvant properties, that is, a very small quantity of it increases the killing power of insect repellents made from Pyrethrum. There is no production of it in Australia, but small amounts are imported from Kenya. *M. viridiflora* yields an oil which may acquire future importance as a commercial source of the perfumery alcohols, linalool and nerolidol. (A. R. Penfold, *Perf. & Ess. Oil Rec. 48(2): 59. 1957*).

BOOK REVIEWS

El Maguey y el Pulque en los Codices Mexicanos. Oswaldo Gonçalves de Lima. 244 pages. Fondo de Cultura Económica. 1956.

A very good example of Mexican bookmaking has appeared under this title, the work of a Brazilian student of fermented beverages used by the aboriginal Americans. Having previously covered his subject in the South American countries ("Observações sôbre o 'vinho da Jurema', utilizado pelos índios Pancarú de Tacaratú (Pernambuco)", en *Arq. I. P. A.* Recife, 45–80. 1946) and comparisons with Asiatic drinks, the author extended his investigations to Mexico. He has presented analytical data regarding the maguey plant and the beverage, pulque, which is made from it, and has traced the drink back through history. For the former, he has reviewed the scientific literature, and for the latter, he has examined numerous codices, including: Boturini, Chimalpopoca, Florentine (Sahagun), Magliabecchi, Vatican B, Borgia, Bologna, Fejérváry-Mayer, Mendoza, Vindobonensis, Zouche-Nuttall, Aubin Tonalámatl, Borbonicus, Telleriano-Remensis, Xólotl, Texupan, and the Badianus manuscript. The book is generously illustrated with pertinent figures from the various sources, 72 in all, plus a colored frontispiece.

Along with his studies and interpretations of the historical material, Professor Lima has gleaned data from Mexican authorities, and has added new information.

The work includes more than 450 bibliographic and footnote references. Published in Spanish, the writing is simple, direct and easily comprehensible. The scientific identifications, historical presentations, mythological aspects and ceremonial involvements should make this publication of profitable use to ethnobotanists, historians, anthropologists and many others.

The sewed binding permits of the book's opening and lying flat for facile handling, and the open style and size of type make for easy reading. The Fondo de Cultura Económica may well be proud of its accomplishment.

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Textbook of Pharmacognosy. T. E. Wallis. 3rd Ed. xi + 578 pages. J. & A. Churchill Ltd., London (distributed by Little, Brown, and Company, Boston, Mass.). 1955. $7.50.

This is a standard English class book in the subject, built around a morphological scheme of classification, a presentation which was previously so popular in American texts (Maisch, Wall, Sayre, Mansfield, and others). The great majority of drugs considered are of current interest to American students, although there are included a few which are rarely heard about or used in this country, for example, Oliver bark, rose hips (haws), cherry laurel, adhatoda, cutch and bael). On the other hand, some important items in America have been omitted. They include spearmint and several other Labiate herbs; cubeb, pepper and other spices; rutin, pectin, sweet orange peel, *Viburnum opulus*, chenopodium, coffee (with a mere mention), camphor (!!), Indian rhubarb, chicory (except as an adulterant); the enzymes papain, diastase and taka-diastase; coconut oil and other *Cocos* products; lactose; corn, palm and some other fatty oils; tars of pine, coal, juniper and other materials; *Serenoa* (saw palmetto berries), juniper berries, many volatile oils (rose, juniper, etc.), many native American drugs (such as Cimicifuga and Chamaelirium), erigeron, and many other minor drugs. Penicillin is the only antibiotic discussed, and this very briefly. On checking against the previous edition, it was found that some obsolete items, for instance, ispaghula, had been deleted.

From the botanical viewpoint, family classifications are sometimes antedated, such as Cannabinaceae for Moraceae. Unfortunately,

author names for species are not always included (*Gossypium*, p. 38; *Cinchona*, p. 89).

In the first edition difficulty was sometimes encountered in locating papers cited in a skeleton manner (author, date); an appended bibliography covering ten pages gives great assistance here, but unfortunately does not include all the references appearing in the body of the text. A score of errata appearing in the first edition were checked in the latest and found mostly corrected.

A section on " Commercial Relations " appears as the last chapter, an ideal place for such data, since by the time this stage is attained, the student is both familiar with and more interested in the subject matter.

All in all, this book is an excellent example of a concise, accurate and well balanced British textbook.

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